DOUBLE NUMBER

VOL. XXXVIII SEPTEMBER, 1922 Nos. 1 & 2

JOURNAL

OF THE

Elisha Mitchell Scientific Society

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ISSUED QUARTERLY

CHAPEL HILL, N. C., U. S. A.

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JOURNAL OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY—Quarterly. Price $3.00 per year; double numbers, $1.50. Numbers for sale are listed inside the back cover. Direct all correspondence to the Permanent Secretary, at the University of North Carolina, Chapel Hill, N. C.

In addition to original papers on scientific subjects this Journal publishes the Proceedings of the Elisha Mitchell Scientific Society, and the Proceedings of the North Carolina Academy of Science, as well as abstracts of papers on scientific subjects published elsewhere by members of the Faculty of the University of North Carolina.

Published for the Society
by the
University of North Carolina

BY RESOLUTION OF

THE ELISHA MITCHELL SCIENTIFIC SOCIETY

AND

THE NORTH CAROLINA ACADEMY OF SCIENCE

THIS NUMBER IS DEDICATED

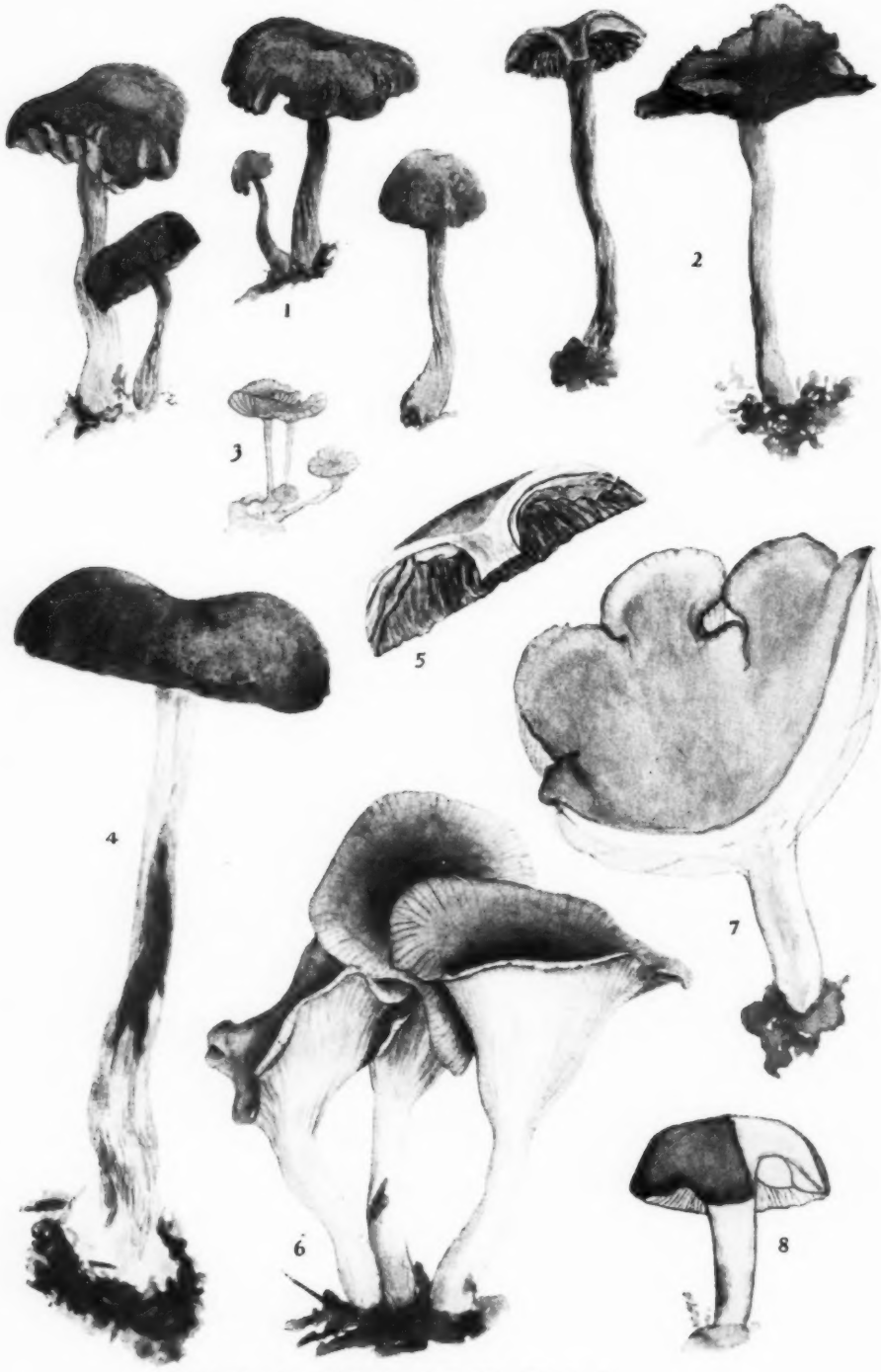
TO THE MEMORY OF

CHARLES BASKERVILLE

BORN 1870

DIED 1922

PLATE 1



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Clititocybe subnigricans (young plant). No. 3357, fig. 8.

JOURNAL

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Elisha Mitchell Scientific Society

Volume XXXVIII SEPTEMBER Nos. 1 and 2

PROCEEDINGS OF THE TWENTY-FIRST ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

HELD AT CHAPEL HILL, N. C., MAY 5 AND 6, 1922

The Executive Committee met Thursday night at the Faculty Club of Trinity College with the following members present: J. L. Lake, president, Bert Cunningham, secretary, F. A. Wolf, R. N. Wilson, and H. R. Totten.

The following recommendations were adopted for presentation to the Academy:

1. That the business meeting of the Academy shall be held on Friday afternoon at 4:30.

2. That a special committee consisting of the president, the editor of the ELISHA MITCHELL JOURNAL and the secretary be appointed to revise and publish the constitution and membership list and consider the advisability of adding to this a brief history of the Academy, getting the whole out in booklet form for distribution to prospective members.

3. That the fiscal years be changed from January to January to October to October so that it may coincide with the A. A. A. S. year, and the Elisha Mitchell year.

4. That the secretary be authorized to discontinue the practice of placing papers on the program in the order of their arrival, and to arrange the program as deemed best in his judgment.

5. That a loose-leaf system of records and accounts be adopted.

6. That the old secretary's book be rebound.

7. That the secretary be authorized to have reprints of the proceedings made for distribution to interested parties.

8. That the Academy pay to the ELISHA MITCHELL JOURNAL the sum of $125.00 for the Journals to the membership rather than the $75.00 now paid. The latter price was based upon a membership of 100. There are now 163 members.

The following were then elected to membership: J. F. Dashiell, J. F. Daugherty, L. M. Dixon, J. E. Eckert, C. O. Eddy, N. B. Foster, E. H. Frothingham, F. A. Grant, F. Haasis, M. L. Hamlin, C. H. Higgins, A. L. Hook, C. F. Korstian, W. E. Jordan, E. C. Linderman, Mary Lyon, I. H. Manning, A. C. Martin, Bessie Noyes, K. B. Patterson, W. L. Porter, R. S. Pritchard, Mrs. J. C. Root, P. O. Schallert, F. W. Sherwood, H. G. Smith, S. C. Smith, J. H. Taylor, M. F. Trice, G. W. Vaughn, F. C. Vilbrandt, Ruth Walker, N. F. Wilkerson, C. F. Williams, W. T. Wright, L. E. Yocum.

The following were reported as resigning: J. S. Downing, H. Spencer, M. R. Smith, C. B. Williams. All resignations due to removal from the state.

The secretary-treasurer then made a financial report which is printed elsewhere.

The secretary reported the adoption of a policy of notifying members when their titles for papers were received.

The committee extended the time for Dr. A. Henderson's paper on Einstein to 45 minutes, and then adjourned to meet Friday at 2:30. There was no new business presented at the Friday meeting of the committee.

The Academy was called to order Friday morning by President Lake and the presentation of papers was begun. After the appointment of the following committees the Academy adjourned at 1:20 for lunch:

Nominating—C. S. Brimley, H. V. Wilson, C. W. Edwards.

Auditing—W. C. Coker, R. N. Wilson, J. P. Givler.

Resolutions—W. A. Withers, H. N. Gould, Miss Mary Seymour.

After lunch many visited the flower show at Davie Hall which served as a demonstration for Mr. Totten's paper, as shown on the program. At 3:00 o'clock the Academy re-convened and the reading of papers was continued until 5:45 when the Academy adjourned until 8:00 p. m.

The evening meeting was called to order by the secretary who introduced President Chase of the University who welcomed the Academy and spoke a few well-chosen words as to the relation of science to daily life. President Lake of the Academy responded and then delivered the Presidential Address on "The Search for the Ultimate Atom." This was a timely review of the various discoveries which have led to our modern ideas of matter. The Academy then called for the paper by Mr. C. S. Brimley—"Twenty Years of the North Carolina Academy of Science." This paper was highly appreciated as it was given by one who has been with the organization since its birth. An informal "get-to-gether" was enjoyed after adjournment.

At nine o'clock Saturday morning the Academy opened with a business meeting. Reports of Committees were first called for.

The Committee on Natural Resource Conservation reported, and the Committee was continued.

The Representative of the Academy on the Council of the American Association made a report.

The Auditing Committee reported the books of the Treasurer as satisfactory.

The Publicity Committee reported some progress, but was somewhat uncertain as to what was expected of it. After further instruction the committee was continued.

The Committee on High School Science reported, and the committee on the order of the Academy was reorganized as follows: Chairman—Bert Cunningham; J. N. Couch, R. N. Wilson, and A. F. Roller.

The Legislative Finance reported no progress.

The Executive Committee reported and all the recommendations shown above were adopted.

The Treasurer gave a summarized report as follows:

RECEIPTS

Saving Account former Treasurer	$196.98
Dues	438.79
	$635.77

EXPENDITURES

Current Expenses	$141.85
A. A. A. of S.	158.00
	$299.85
Balance Saving Account	200.00
Balance Check Account	135.92
	$635.77

The Academy ordered the Secretary to send the following telegram to Dr. E. W. Gudger—"N. C. A. S. in session at the University sends you hearty greetings and is glad to report that the treasurer's balance is now $370.00."

The Resolutions Committee reported as follows:

The Committee on Resolutions very respectfully recommends the adoption of the following:

1. That the Academy place upon record its appreciation of the services of its officers who have arranged such an attractive program and secured such a large attendance.

2. That the thanks of the Academy are due to our gracious hosts who have so charmingly entertained its members during the present meeting.

3. That the Academy dedicate the volume of the Journal of the Elisha Mitchell Society containing the report of the Proceedings of this meeting to the memory of the late Dr. Charles Baskerville, one of its earlier members, one of its very active workers, and at one time its President.

W. A. WITHERS,
MARY SEYMOUR,
H. N. GOULD.

The Nominating Committee presented the following for office and they were elected by the Academy:

President—Dr. A. Henderson, University of North Carolina.

Vice-President—Dr. H. B. Arbuckle, Davidson College.

Secretary-Treasurer—Dr. Bert Cunningham, Trinity College.

Executive Committee—Dr. H. N. Gould, Wake Forest, Professor J. P. Givler, N. C. College for Women, Dr. B. W. Wells, State College.

The time for the Annual Meeting was discussed, and was finally left in the hands of the Executive Committee as in the past.

The invitation to hold the next meeting in Greensboro at the N. C. College for Women was announced and accepted.

At 11:00 papers were presented to the joint meeting, and at 11:30 the Chemists and Physicists adjourned to other quarters to hold their separate meetings. Their papers are shown on the following programs. The last paper was read just before lunch time and the Academy adjourned.

Following is the present membership of the Academy. Those marked with an asterisk were present at the meeting.

Andrews, W. J., Civil Engineer.....Raleigh
*Arbuckle, H. B., Professor of Chemistry, Davidson College.....Davidson
Babb, J. S., University of North Carolina.....Chapel Hill
Bahnson, F. F., 28 Salisbury Road.....Winston-Salem
*Baker, Miss Lucretia, Meredith College.....Raleigh
Balderston, Mark, Guilford College.....Guilford College
Barnes, J. T.....Roanoke Rapids
Barret, H. P., 211 Vail Ave.....Charlotte
Barrow, Miss Elva E., Chemistry Dept., N. C. College for Women....Greensboro
*Bell, J. M., Dept. of Chemistry, University of North Carolina.....Chapel Hill
Binford, Raymond, President Guilford College.....Guilford College
Bonney, Miss E. C., 1421 Fourteenth Ave.....Hickory
Bottum, Miss F. R., St. Mary's School.....Raleigh
*Blomquist, H. L., Dept. of Biology, Trinity College.....Durham
*Brimley, C. S., Division of Entomology, N. C. Dept. of Agriculture.....Raleigh
Brimley, H. H., Curator State Museum.....Raleigh
Browne, Wm. Hande, Dept. of Electrical Engineering, State College.....Raleigh
Bruner, S. C., Estacion Agronomica.....Santiago de las Vegas, Cuba
*Bullitt, J. B., Professor of Pathology, Univ. of North Carolina.....Chapel Hill
Bureh, Wayne, Trinity College.....Durham
Cain, William, Kenan Prof. Emeritus of Math., Univ. of N. C.....Chapel Hill
Campbell, Miss Eva G., Dept. Biology, N. C. College for Women.....Greensboro
Clapp, S. C., Superintendent State Test Farm.....Swannanoa
*Cobb, Collier, Professor of Geology, Univ. of N. C.....Chapel Hill
Cobb, William B., Louisiana State University.....Baton Rouge, La.
*Coker, W. C., Kenan Professor of Botany, Univ. of N. C.....Chapel Hill
Collett, R. W.....White Hall, S. C.
*Couch, J. N., Dept. of Botany, University of North Carolina.....Chapel Hill
*Cunningham, Bert, Professor of Biology, Trinity College.....Durham
Dashiell, J. F., Prof. of Psychology, Univ. of North Carolina.....Chapel Hill
Daugherty, J. F., Dept. Physics, Univ. of North Carolina.....Chapel Hill
Davis, Harry T., Assistant Curator State Museum.....Raleigh
Denson, Lee A., U. S. Weather Bureau.....Raleigh
*Derieux, J. B., State College.....Raleigh
Dixon, A. A., State College.....Raleigh

*Eckert, J. E., Dept. Zoology, State College.....Raleigh
*Eddy, C. O., Dept. Zoology, State College.....Raleigh
*Edwards, C. W., Professor of Physics, Trinity College.....Durham
Farmer, C. M., 115 Orange Street.....Troy, Ala.
*Farrington, R. K., Med. Student, Univ. of North Carolina.....Chapel Hill
*Foster, N. B., Dept. of Physics, State College.....Raleigh
*Frothingham, E. H., U. S. Silviculturist.....Asheville
*George, W. C., Asso. Prof. Histology and Embryology, Univ. N. C...Chapel Hill
*Givler, J. P., Professor of Biology, N. C. College for Women.....Greensboro
*Gould, H. N., Dept. of Biology, Wake Forest College.....Wake Forest
*Grant, F. A., Asst. in Botany, University of North Carolina.....Chapel Hill
*Gross, P. M., Dept. of Chemistry, Trinity College.....Durham
Groves Miss Pattie J., 802 Watts Street.....Durham
Gudger, E. W., American Museum of Natural History.....New York City
*Halverson, J. O., Dept. of Agriculture.....Raleigh
Haber, V. R., Division of Entomology, N. C. Dept. of Agriculture.....Raleigh
Hatley, C. C., Columbia University.....New York City
*Heck, C. M., Dept. of Physics, State College.....Raleigh
*Henderson, Archibald, Prof. of Mathematics, Univ. of N. C.....Chapel Hill
*Hickerson, T. F., Prof. Civil Engineering, Univ. of N. C.....Chapel Hill
Hobbs, A. W., Asso. Prof. Mathematics, Univ. of N. C.....Chapel Hill
Hoffman, S. W.,.....Statesville
*Holland, Miss Alma, Dept. of Botany, Univ. of N. C.....Chapel Hill
*Holmes, J. S., State Forester.....Chapel Hill
Haasis, F., Forest Examiner.....Asheville
*Hamlin, M. L., Indust. Chemist, Trinity College.....Durham
*Higgins, C. H., Dept. of Science, Salem College.....Winston-Salem
Hook, A. L., Dept. of Physics, Elon College.....Elon College
Ives, J. D., Stetson University.....Deland, Fla.
Ivey, J. E., State College.....Raleigh
*Jordan, W. E., State College.....Raleigh
*Jones. E. P., Indust. Chemist, Trinity College.....Durham
Kilgore, B. W., Director of Experiment Station.....Raleigh
Korstian, C. F., Forest Examiner.....Asheville
Krausz, H. B.....Raleigh
*Lake, J. L., Professor of Physics, Wake Forest College.....Wake Forest
*Lasley, J. W., Jr., Asso. Prof. Math., Univ. of N. C.....Chapel Hill
Lehman, S. G., State College.....Raleigh
Leiby, R. W., Division of Entomology, N. C. Dept. of Agriculture.....Raleigh
Lewis, R. W., Citizens Bank Building.....Raleigh
Lugn, A. L., Dept. of Chemistry and Physics, Lenoir College.....Hickory
Linderman, E. C., Dept. of Sociology, Greensboro College.....Greensboro
Lyon, Mary, Dept. of Biology, Greensboro College.....Greensboro
*Mabee, W. Bruce, Division of Entomology, N. C. Dept. Agriculture.....Raleigh
*MacNider, W. DeB., Kenan Prof. of Pharmacology, Univ. of N. C....Chapel Hill
Marion, S. J., Dept. of Chemistry, State College.....Raleigh
Markham, Blackwell.....Durham

Mendenhall, Miss Gertrude, 1023 Spring Garden Street.....Greensboro
*Metcalf, Z. P., Prof. of Zoology and Entomology, State College.....Raleigh
*Mitchell, T. B., Division of Entomology, N. C. Dept. Agriculture.....Raleigh
*Manning, I. H., Dean Med. School, Univ. of N. C.....Chapel Hill
*Martin, A. C., Dept. of Botany, State College.....Raleigh
*Nixon, L. M., Chemist, Dept. of Agriculture.....Raleigh
Nowell, J. W., Wake Forest College.....Wake Forest
*Noyes, Bessie, Dept. H. Biology, N. C. College for Women.....Greensboro
*Patterson, A. H., Prof. of Physics, Univ. of North Carolina.....Chapel Hill
*Paull, N. M., Assistant Prof. of Drawing, Univ. of N. C.....Chapel Hill
Pegram, W. H., Dept. of Chemistry, Trinity College.....Durham
Petty, Miss Mary, N. C. College for Women.....Greensboro
*Phillips, Charles, Dept. of Pathology, Wake Forest College.....Wake Forest
Pillsbury, J. P., State College Station.....Raleigh
Plummer, J. K., 499 Courtland Street.....Atlanta, Ga.
Poteat, W. L., President Wake Forest College.....Wake Forest
*Powell, T. E., Jr., Professor of Biology, Elon College.....Elon College
Pratt, J. H., State Geologist, Univ. of North Carolina.....Chapel Hill
*Prouty, W. F., Prof. of Stratigraphic Geology, Univ. of N. C.....Chapel Hill
*Patterson, K. B., Assistant Prof. of Math., Trinity College.....Durham
*Porter, W. L., Prof. of Biology, Davidson College.....Davidson
*Pritchard, R. S., Chemistry Dept., Wake Forest College.....Wake Forest
*Randolph, E. E., Chemistry Dept., State College.....Raleigh
Randolph, E. O.....College Station, Texas
Randolph, Mrs. E. O.....College Station, Texas
Rankin, W. S., State Board of Health.....Raleigh
*Rhodes, L. B., Division of Chemistry, N. C. Dept. Agriculture.....Raleigh
Robinson, Miss Mary.....Wadesboro
*Roller, A. F., High School.....Raleigh
Ruffner, R. H., State College.....Raleigh
Root, J. C., Mrs., High School.....Raleigh
*Satterfield, G. H., Trinity College.....Durham
*Saville, Thorndike, Asso. Prof. Engineering, Univ. N. C.....Chapel Hill
*Seymour, Miss Mary F., N. C. College for Women.....Greensboro
Shaffer, Miss Blanche E., N. C. College for Women.....Greensboro
Sherrill, Miss Mary L., Mt. Holyoke College.....S. Hadley, Mass.
Sherrill, Miss Mildred, High School.....Henderson
Sherwin, M. E., State College.....Raleigh
Sherman, Franklin, Entomologist, N. C. Dept. Agriculture.....Raleigh
Shore, C. A., State Laboratory of Hygiene.....Raleigh
*Shunk, I. V., 222 West Morgan Street.....Raleigh
Smith, J. E., Iowa State College.....Ames, Iowa
*Smith, S. C., Dept. of Chemistry, Univ. of N. C.....Chapel Hill
*Speas, William E., Dept. of Physics, Wake Forest College.....Wake Forest
Stiles, C. W., Hygienic Laboratory.....Washington, D. C.
*Stuhlman, Otto, Jr., Dept. Physics, Univ. of N. C.....Chapel Hill
*Sullivan, R. W., Chemical Dept., Wake Forest College.....Wake Forest

*Schallert, P. O.....Winston-Salem
*Sherwood, F. W., Chemist, Dept. of Agriculture.....Raleigh
*Smith, H. G., State College.....Raleigh
*Taylor, J. H., Grad. Student, Trinity College.....Durham
Taylor, C. C., State College.....Raleigh
*Taylor, Haywood, M., Dept. of Chemistry, Univ. of N. C.....Chapel Hill
*Taylor, W. F., Wake Forest College.....Wake Forest
Thies, O. J., Jr., Dept. of Chemistry, Davidson College.....Davidson
*Totten, H. R., Dept. of Botany, Univ. of N. C.....Chapel Hill
*Trice, M. F., State College.....Raleigh
*Vann, H. M., Dept. of Anatomy, Wake Forest College.....Wake Forest
*Venable, F. P., Kenan Prof. Chemistry, Univ. of N. C.....Chapel Hill
*Wells, B. W., Dept of Botany, State College.....Raleigh
*Wells, Mrs. B. W., State College Station.....Raleigh
*Vaughn, G. W., Asst. Prof. Engineering, Trinity College.....Durham
*Vilbrandt, F. C., Prof. Indust. Chemistry, Univ. of N. C.....Chapel Hill
*Walker, Ruth, Dept. Biology, N. C. College for Women.....Greensboro
*Wheeler, A. S., Dept. of Chemistry, Univ. of N. C.....Chapel Hill
Wilkerson, N. F., Grad. Asst. Biology, Trinity College.....Durham
*Williams, C. F., Dept Horticulture, State College.....Raleigh
*Wright, W. T., Dept. Physics, N. C. College for Women.....Greensboro
Williams, C. B., State College Station.....Raleigh
Williams, J. H., High School.....Raleigh
*Williams, L. F., State College.....Raleigh
Wilson, Donald B., State College.....Raleigh
*Wilson, Henry V., Dept. of Zoology, Univ. of N. C.....Chapel Hill
*Wilson, R. B., Dept. of Biology, Wake Forest College.....Wake Forest
*Wilson, R. N., Dept. of Chemistry, Trinity College.....Durham
*Winston, Lula G., Meredith College.....Raleigh
Winters, R. Y., State College.....Raleigh
*Withers, W. A., Dept. of Chemistry, State College.....Raleigh
*Wolf, F. A., Plant Pathology, State College.....Raleigh
Wright, Miss Eva K., Dept. of Chemistry, N. C. College for Women..Greensboro
*Yocum, L. E., Dept. of Biology, N. C. College for Women.....Greensboro

The following papers were presented:

The Search for the Ultimate Atom. J. L. Lake. (Presidential Address.) Historical review of the discoveries leading up to the modern ideas of matter. Appears in full in this issue.

Twenty Years of the North Carolina Academy of Science. C. S. Brimley. Appears in full in this issue.

Coördinate Systems in Mathematics. J. W. LASLEY, JR.
Descartes in the seventeenth century furnished mathematicians

with the means of attacking geometric situations by means of analysis. It is now one of the problems of the mathematician to adapt to a problem that particular system of coördinates best suited to it. In trying to do this many kinds of coördinate systems have arisen. One of these, namely homogeneous coördinates, besides possessing marked power in itself, includes many of the more frequently used systems as particular cases. A detailed and connected account of this system is a need keenly felt by students of mathematics. This paper points out this need, and suggests lines along which this account may be developed.

A Note on the Pulmonary Circulation in Vertebrates. W. C. GEORGE.

Some anomalies in the pulmonary veins of man were described. Attention was called to the correspondence between the atypical condition in these anomalies and the typical relations of the vascular drainage of the air-bladders of some fishes.

Notes on Protozoa. BERT CUNNINGHAM.

The report consisted of two parts. The first was a systematic study of the forms occurring near Durham. The following classes and orders were observed:

Class Rhizopoda		29
Order Gymnamoebida	5	
Testacea	24	
Class Actinopoda		2
Order Aphrothoracida	2	
Class Zoomasiigophora		18
Order Monadida	1	
Phytomastigida	2	
Euglenida	11	
Diniferida	4	
Class Ciliata		44
Order Holotricha	19	
Heterotricha	12	
Hypotricha	8	
Periotricha	5	
Class Phytomastigophora		3
Order Chrysoflagellata	1	
Chloroflagellida	2	
	96	96

No attempt was made to study the Sporozoa.

The second part was the presentation of a number of rare forms which had not yet been identified by the writer. Among these rare forms was a species of *Tintinnus* observed in the Plankton Collections* of Chesapeake Bay (fig. 1). It bears the characters of the genus, with the following specific characters:

Length 0.275 mm. Diameter 0.05 mm.

Cylindrical with corrugated constriction near the interior end; nucleus single.

It was observed but once in some four hundred collections averaging about 2,000 individuals per collection. Found in a bottom collection (23.79 meters) taken just off Cape Henry, July 9, 1920.

FIG. 1

New Dyes Derived from 5-Chloro-2-amino-p-cymene. A. S. WHEELER and I. V. GILES.

A new series of dyes was obtained by coupling the diazo salt of 5-chloro-2-amino-p-cymene with the following compounds: 1, Beta-naphthol (dyes wool scarlet); 2, Alpha-naphthol- (dyes wool claret brown); 3, Phenol (dyes wool capucine yellow); 4, Salicylic acid (dyes wool Mars orange); 5, Resorcinol (dyes wool Brazil red); 6, Alpha-naphthol-2-sulfonic acid (dyes wool burnt Sienna); 7, Beta-naphthol-7-sulfonic acid (dyes wool scarlet); 8, Alpha-naphthol-4-sulfonic acid (dyes wool scarlet). Silk dyeings show different shades from those indicated for wool.

A "Nature-Experiment" on the Development of Frogs and One on the Physiology of Sponges. H. V. WILSON.

In an artificially inseminated batch of eggs of *Hyla pickeringii*, a large number exhibited an abnormality which may with justice be reasoned from as if it were the result of a planned experiment. In these embryos the tail begins to grow out as a pair of buds at a time when the exposed yolk area is so large that in side view it forms one-third to one-fourth the total circumference. Except in the mid-dorsal region where the archenteron has an actual aperture there is

* Collections taken by the U. S. Fisheries for a Biological and Hydrographical Survey which is as yet incomplete.

only a virtual blastopore lip, that is, laterally and ventrally the ectoderm and yolk cells are not set off from one another by a groove. This virtual blastopore lip which on the concrescence hypothesis contains the material destined to form the axial organs of the embryo, *gradually closes along the ventral surface of the tail and at the posterior end of the body.* This fact forms additional evidence for the view that concrescence, although it may occur in teratological embryos, is not a constant or basic process in the embryogeny of a vertebrate body.

The recorded observations on the Phloeodictyine sponges leave in doubt the question whether the tubes (fistulae) which project from the body carry the currents of water outwards, inwards, or perhaps in both directions. A specimen of *Phloeodictyon putridosum* taken by U. S. Bureau of Fisheries Steamer Albatross, in the Philippines, seems to answer this question, which no one has yet had the opportunity of studying on the living sponge. The specimen referred to is spheroidal, 115 mm. in diameter, and bears about forty fistulae on its upper and lateral surfaces. Just beneath the natural surface of the body a calcareous alga, one of the *Corallinaceae*, of branching, filamentous habit, has formed a practically solid calcareous layer 5 mm. thick. This layer, interrupted only by the fistulae, extends all over the sponge body. The interior of the sponge is thus left in connection with the surrounding water only through the fistulae, which, it is therefore obvious, must conduct currents both inwards and outwards.

The Stems of Grape Hybrids. C. F. WILLIAMS.

A study of transverse and longitudinal sections of mature one-year wood of *Vitis vinifera*, *V. rotundifolia* and their F_1 hybrids shows the pattern of the phloem tissue and the character of the cork cambium to be specific. In *V. vinifera* the pattern is square in outline with alternate tangential layers of hard and soft bast, prominent cork cambium and a large sclerenchyma bundle externally. The rays extend intervascularly without expansion, the open ends acting as lenticels. In *V. rotundifolia* the pattern is triangular, the hard bast outlining the soft radially, with a small sclerenchyma bundle inside the cork cambium. The rays expand in the vascular region by tangential division. Typical lenticels are present and the cork cambium inconspicuous. The F_1 hybrids of this cross show inter-

mediate characters of great variation, especially in regard to cork cambium, demonstrating that anatomical characters are inherited as well as the ones of color, size, weight, etc., usually studied.

Wild Ferns and Flowers of Chapel Hill. H. R. TOTTEN.

The Department of Botany, with the assistance of the classes in Botany 1 and 2, brought in wild plants found in flower during the first week in May. These were put on display for two days, so that the botany students and others interested in our native plants could familiarize themselves with them. One hundred and seventy-one plants were displayed in flower. This number includes thirty-four naturalized weeds and fourteen escapes. The Virginia Spiderwort *(Tradescantia virginiana)* and the White Bladder Campion *(Silene alba)* have not been previously reported from Chapel Hill. Not included in the number given above were several plants not in complete flower, also twelve ferns and one of the fern allies.

The Calcium Content of Mixed Feeds in Relation to the Feeding Requirement of Animals. J. O. HALVERSON and L. M. NIXON.

Dr. Forbes and associates of the Ohio Agricultural Experiment Station showed that in heavy milking cows there is an actual shortage or loss of calcium from the body. Perhaps a higher calcium content of mixed feeds for animals under domestication is necessary. Concentrated dairy feeds require a somewhat higher, more carefully regulated calcium content. The addition to mixed feeds relatively low in calcium of such high calcium-containing substances as alfalfa leaf meal, meat, and ground bone to poultry and hog feeds, and beet pulp, alfalfa meal, or calcium carbonate to dairy feeds, is a commendable and beneficial practice. Actual intensive feeding practice strengthens this belief. Recent work on the importance of the mineral elements in nutrition has shown that they are fundamentally necessary in the growth of farm animals as well as in the animals of the laboratory; that they are as necessary in the ration as is a protein of both adequate quality and quantity.

Studies on Fermentation of Rare Sugars by Plant Pathogenic Bacteria. F. A. WOLF.

Organisms from the same host may be indistinguishable on the basis of their ability to ferment the carbohydrates of the Descriptive Chart. The fermentation of rare sugars has, therefore, been used as

a means of identification of these closely related organisms. In the case of two leafspot diseases of tobacco commonly designated as wildfire and angular leafspot caused by *Bacterium tabaccum* and *B. angulatum* respectively, both are able to form acid from dextrose and saccharose but not from glycerine and lactose, but the farmer attacks in addition mannitol and galactose whereas the latter is without action on them. A similar specialization obtains in the case of two leafspot organisms, *Bacterium glycineum* and *B. sojae* from soybean. This study emphasizes the necessity of employing in phytopathological studies the rare sugars for diagnostic purposes.

Pod and Stem Blight of the Soybean. S. G. LEHMAN. (Read by F. A. WOLF).

This disease is capable of causing serious damage to the soybean, particularly in wet seasons. It attacks pods, stems, and less frequently, leaves, but greatest apparent loss results from attacks on pods. Very young pods drop off when attacked, but older ones remain firmly attached. The causal fungus penetrates the pod wall and invades the developing seed. The ovule may abort at an early stage, or, if attacked later in its development, the seed becomes shriveled to various degrees depending on the time and severity of infection. Seeds in diseased pods are often completely invested with a conspicuous white fungus covering. Diseased areas on stems, pods, and leaves become specked with minute black fruiting bodies, pycnidia, which begin exuding small, hyaline, single celled spores within a few days after their appearance.

The causal fungus is placed in the form genus *Phomopsis*, and in reference to its host, it is assigned the binomial "*Phomopsis sojae.*" It has been isolated from stems, pods, and seed, and has been observed to cause the death of seedling soybean plants by growing from the seed coat onto the hypocotyl and causing its decay. It overwinters in diseased stems and seed. The practice of such sanitary measures as plowing under diseased plants after harvest, use of disease-free seed, and crop rotation are recommended as control measures.

Variation of Protein Content of Corn. H. B. ARBUCKLE and O. J. THIES.

Appears in full in this issue.

Some Phases of Structure and Development of Garden Pea and White Sweet Clover Seeds as Related to Hardness. L. E. YOCUM.

Appears in full in this issue.

Notes on the Reproduction of Hydra in the Chapel Hill Region. H. S. EVERETT.

Appears in full in this issue.

Dormancy in Seeds of Persimmon (Diospyros virginiana). H. L. BLOMQUIST.

A preliminary report on an investigation in germinating seeds of persimmon, showing that there is a marked period of dormancy under both natural and artificial germinating conditions. The length of this period has not been definitely determined but seems to extend over two to several years, depending upon the physical, chemical, and biological conditions of the soil and upon the location of the seed and the variation in its structure. The main cause of the delay in germination has been found to be due to a layer of the seed covering which caps the radicle and exerts a certain amount of resistance to the expansion of the embryo and a decrease in water absorption. By removing this cap one hundred per cent germination was secured with seeds collected in the autumn from mature fruit.

Some Investigations into the Bacteriology of Common Colds and an Autogenous Vaccine Therapy for Six Months at Wake Forest College. W. L. TAYLOR and CHARLES PHILLIPS.

In the fall of 1921 bacteriological cultures were made from the noses or throats of 25 persons having fresh colds. Growth was made in dextrose blood broth and on dextrose blood agar plates, reaction Ph 7.2, the broth tubes incubated anaerobically and the plate aerobically. Incidental saprophytic bacteria were largely ruled out by this method. The organisms identified and obtained in pure culture were: *Staphylococcus albus* and *aureus*, *B. Mucosus capsulatus* (Friedlander), *Streptococcus hemolyticus* and *viridans* type, *Micrococcus tetragenus* and *catarrhalis*, *Pneumococcus* types 2 and 4, *B influenza*, and two strains of *Diphtheroids*. Several strains of most of these were obtained. A polyvalent vaccine of these was made and standardized to contain 1000 million per cc. This was given by the usual technique hypodermically every 4-5 days in these doses, .25cc,

.50cc, .75cc, 1cc repeated twice, six doses for the whole treatment. Of 35 people reporting for doses, only 20 reported with regularity allowing tabulation, which was carefully done in detail to check claims against actual results. A column of figures in percentages shows actual findings. The summary gives several interesting points of discussion. Here is a group of common colds, 25 in number, occurring in an average college community, and from which were isolated 10 different organisms of varying pathogenicity. A polyvalent autogenous vaccine made up from these was found to be relatively nontoxic in the dosage used in spite of the nature of some of them. In treating these cases there was found to be no constant relationship between the number of doses taken and freedom from colds during the trial period of October to April, 2% getting absolute protection, while 70% had one or more colds after the last dose, all living under comparable conditions. This is true also for those cultured or not cultured, suggesting little if any specificity for the vaccine. Over half of those treated claim some benefit from its use, in reduced severity of colds contracted and number expected, judging from previous experience during these months. Not enough people took the full six doses, making this group too small to draw conclusions from. The attitude of the members of this group towards this vaccine trial is partially shown by 65% of them stating their probable willingness to try something similar next winter.

Some Intestinal Cestode and Nematode Parasites of Cats of Wake Forest, N. C. R. B. WILSON. (Body of the paper accepted as a thesis for the M. A. degree, 1922.)

The writer made at Wake Forest College an examination of the intestines of 25 cats for Cestode and Nematode parasites. The report gives an account of the material used and the method of study followed. The result of the study can best be given in the form of a table showing the relative number of each kind of parasite, as follows:

Number of Cats	Taenia crassicollis	Dipylidium caninum	Ascaris mystax	Anchylostomum trigonocephalum	Unidentified Nematode of Large Int.
25	60	150	106	13	Many

The unidentified nematode of the large intestine was very small, measuring 320 to 432 microns in length by 10 to 19 microns in thickness. These worms had the general appearance of larvae, but

no intermediate developmental stages were found, and no adult worm was found in the alimentary canal from which it could come. The investigation of this organism is continuing.

The Age of the Ocoee and Associated Rocks of Clay County, Alabama. W. F. PROUTY.

The geological age of many of the rocks occurring in the semi-crystalline area in the southern Appalachians has long been in doubt. Dr. Safford of Tennessee, in 1856, assigned the Ocoee to the Potsdam Group (Cambrian). Arthur Keith of the U. S. Geological Survey, working in portions of Tennessee and North Carolina in more recent times, demonstrated the conformity of the Ocoee with the fossiliferous Cambrian. In 1903 Dr. Eugene A. Smith of the Alabama Geological Survey discovered Carboniferous fossils in a small area of the Talladega Phyllites (the unquestioned equivalent of at least a part of the Ocoee of Tennessee).

It fell to the lot of the author to work out the relationship of this small fossiliferous area to the associated rocks. This work was carried on in the geological mapping of Clay County, Alabama.

The area in which the Carboniferous fossils occur is considerably faulted, but the fault block in which these fossils occur is connected with and proves to be conformable to a series of dark slates and conglomerates underlying it with a thickness of several thousand feet. From a careful study of the sequence of sediments in this area with those in the Coosa and Cahaba Coal Fields, a little to the west, one is brought inevitably to the conclusion that the conglomerate of Talladega Mountain just to the west of and geologically older than the fossil beds is the Millstone Grit of the Pennsylvanian, and that the underlying formations for some distance to the west, in the area of the Ocoee (Talladega), are of Mississippian age.

The Hillabee Schist, a metamorphic basic igneous rock, both cuts across the strike of the Carboniferous Ocoee and intrudes it, thus demonstrating its Post Carboniferous age. A little farther to the east in Clay County areas of altered Talladega (Ocoee) of probable Carboniferous age are intruded by the Pinkneyville granite, thus suggesting if not proving their Post Carboniferous age.

It is thus evident that the Ocoee is a group and that it includes rocks varying in age from Cambrian to Pennsylvanian. It is also evident that some of the larger areas of green schist in contact with

these Ocoee slates are Post Carboniferous, and that some of the larger granitic masses to the east of the Ocoee proper are probably also of Post Carboniferous age.

The Variation of the Photoelectric Current With Thickness of Metal. OTTO STUHLMAN, JR.

Silver and platinum deposited in the form of transparent and semi-transparent wedges were examined for variation of the photoelectric current as thickness of the metal was increased. The metal was deposited on quartz by the evaporation method and examined when monochromatic light fell on the metal side of the plate.

The results are found to be consistent with the view that the probability of an electron going a given distance without losing its ability to escape falls off exponentially with the distance, when this distance is less than about 40 mm. Up to this thickness there is a parallelism between optical absorption and photoelectric emission. For large wave-lengths this parallelism is more pronounced than for short wave-lengths. For greater wave-lengths optical absorption may increase but photoelectric emission decreases terminating at the threshold value of photoelectric sensitivity.

The results seem to support the view that photoelectric emission is probably not caused by the absorption of energy out of the incident light beam, the light only acting as the agent which sets the electron free from its parent atom.

Geology of the Muscle Shoals Area, Alabama. W. F. PROUTY.

Appears in full in this issue.

Chemistry in Its Relation to the State Water Supplies. G. F. CATLETT.

Appears in full in this issue.

The following papers were presented but no abstracts have been received:

The Dipterous Galls of the Hickories. B. W. WELLS. (Lantern).

Instincts in Social Life. (By title). C. C. TAYLOR.

The Effect on Tops of the Wilting of Succulent Vegetables. L. B. RHODES.

The Polymorphic Genus Clavaria. W. C. COKER.

A Review of the Fulgoridae of Eastern North America. Z. P. METCALF.

Striations in Inorganic Solutions. C. M. HECK.

A Parasite of the Mediterranean Flour Moth. J. E. ECKERT. (Lantern).

Spore Discharge in Some Genera of Water Molds. J. N. COUCH.
To appear in full in an early issue of this Journal.

Laboratory Work in Elementary Genetics. C. O. EDDY.

The Echigo Oil Fields, Japan. COLLIER COBB.

Acoustics of Auditoriums. A. H. PATTERSON.

A Review of High School Science Teaching. J. N. COUCH. (Lantern).

Sand Dunes of Niigata. COLLIER COBB.

A New Species of Isoachlya. F. A. GRANT.
To appear in *The Saprolegniaceae*, a volume by W. C. Coker, to be published soon by The University of North Carolina Press.

DEMONSTRATIONS

Wild Flower Show. H. R. TOTTEN and the class in Botany 2.

Abnormal Frog Embryo *(Hyla pickeringii)* with Developed Tail and Exposed Yolk. H. V. WILSON.

A Sponge *(Phlocodictyon putridosum)* with a Shell made up of a Parasitic Calcareous Alga. H. V. WILSON.

Striations in Inorganic Solutions. C. M. HECK.

Laboratory Work in Elementary Genetics. C. O. EDDY.

The following papers were presented to the Physics Section:

How Einstein's Theory of Relativity Was Verified. ARCHIBALD HENDERSON.
In this paper, for which forty-five minutes were allowed, the attempt was made to put into simple terms a *précis* of the general ideas

underlying Einstein's theory of universal gravitation. It was indicated that the differences in results given by the theories of Newton and Einstein are surprisingly small, despite the fact that the theories have few points of resemblance, and proceed from totally different assumptions. The difficulties of finding natural phenomena which will verify Einstein's theory are very great, but finally three were arrived at. These are: the deviation of a ray of light from a rectilinear path, or deflected for example by the attraction of the sun; the advance in the perihelion of Mercury over a period of a century; and the shift of solar light lines to the red end of the spectrum.

Dr. Henderson sketched in outline the fundamental principles of Generalized Relativity, and derived the equation of the curve taken by a ray of light. A figure which was exhibited, as well as the calculations, showed that the deviation according to Einstein's theory, amounted to 1.74″. This figure, which was exactly twice the amount given by the Newtonian theory, was verified (within thirteen per cent) by two astronomical expeditions sent out by Great Britain during the World War, one to Principe, the other to Sobral. Since the time of Leverrier, it has been known that there was a discrepancy of approximately 43″ in a century between the actual advance of the perihelion of Mercury and the computed value according to the Newtonian theory, even allowing for all the known influences. From the equation of the orbit, as computed by the Einstein theory, and the known values of the constants, it was shown that the advance for the perihelion of Mercury came out to be about 43″—a most remarkably accurate determination. Last of all, it was shown by a simple computation that a ray of light from the sun, being of greater wave-length and higher frequency (i. e., redder) than a ray from a terrestrial source, would cause a shift of the spectral lines an appreciable amount toward the red end of the spectrum. Only quite recently, by isolating the solar ray in a vacuum, the French physicist Pérot has shown that the actual shift, for cyanogen, affords entirely satisfactory agreement with the value in Angström units computed according to the Einstein theory.

Effect of an Electric Field Upon Colloids in Non-conducting Liquids. N. B. FOSTER.

X-Ray Spectra from Crystals. J. B. DERIEUX.

Analysis of Crystal Structure from X-Ray Spectra. A. A. DIXON.

The Color of Metals by Transmission. OTTO STUHLMAN, JR. (Lantern).

Use of an Audion Tube as Negative Resistance. D. A. WELLS.

Problems of Research in North Carolina. (By title.) C. W. EDWARDS.

Some Suggestions for the Teaching of Physics. A. H. PATTERSON.

The following papers were presented to the Chemists:

Zirconium Ferrocyanide. F. P. VENABLE and R. A. LINEBERRY.

Zirconium Citrate. F. P. VENABLE and E. C. MOEHLMANN.

Modification of the Official Sodium Method. J. O. HALVERSON, L. E. MORGAN and J. H. SCHULTZ.

The Determination of Potassium in the Official Sodium Method. J. O. HALVERSON and J. A. SCHULTZ.

A Modified Thermoregulator. M. L. HAMLIN.

A Convenient Form of Condenser. M. L. HAMLIN.

Phenolsulphonphthalein and Some of its Derivatives. W. N. ORNDORFF and F. W. SHERWOOD.

Binary Systems of Metanitrotoluene and Another Mononitrotoluene. J. M. BELL and J. L. MCEWEN.

The Nitration of Certain Nitrotoluenes. J. M. BELL and W. B. SMOOT.

The Nitration of Orthonitrotoluene. J. M. BELL and H. G. PICKETT.

The Chlorination of 2-Amino-p-cymene. A. S. WHEELER and I. V. GILES.

New Derivatives of 2-Bromo-5-hydroxy-1,4-Naphthoquinone. A. S. WHEELER and B. NAIMAN.

BERT CUNNINGHAM, *Secretary.*

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, OCTOBER 11, 1921, TO JUNE 2, 1922

250th Meeting—October 11, 1921

Collier Cobb—*Physiographic Processes in Relation to Harbor Development and Harbor Maintenance.*

The observations on which these studies are based have been extended over practically the entire northern hemisphere, and the processes considered are here presented merely in outline. The object of these studies has been to examine into the physical conditions and the physiographic processes that have to do with the formation, preservation, and destruction of harbors. The pursuit of this object is facilitated by a tentative classification of these sheltered waters, based upon the circumstances of their origin; and this leads to an attempted grouping of those various forms of energy, operating upon and within the earth, which tend to improve or to destroy harbors; and, lastly, it is purposed to consider to what extent these natural processes may be affected by the coöperation of man, or by the hindrance that he may offer to Nature's operations.

The forces at work upon our shorelines include all of those agencies for the application of solar energy which are generally described as *gradational*, resulting in the disintegration of rock-masses, and the transportation and deposition of detritus. These atmospheric and aqueous agents effecting gradation may be considered in the following groups: 1. The work of the atmosphere; 2. Rain and rivers; 3. Snow and ice; 4. Wind and waves; 5. Tides and currents; 6. Plants and animals. A comparison of harbors of sub-arctic regions with those of sub-tropical and tropical regions, in essentially similar rocks and rock-structures, will at once reveal the interesting fact that harbors owe their chief characteristics to the processes by which they have been formed, rather than to the geological formations out of which they have been carved.

Besides the forces of gradation just enumerated, which have to do with the application of solar energy, there is another group of agents deriving its energy from the earth itself. This comes from the slow cooling of the earth's mass, its warping, and the creeping

of its crust, producing the movements of subsidence, elevation, and sudden jarring, which take place along the border-line between land and sea. Indeed, there is an everlasting see-saw between the land and sea taking place along the shoreline, and this profoundly affects all harbors. This is especially noticeable on both sides of the North-Pacific, and the changes on our Pacific coast—especially in Alaska—and in Japan, in a single generation, have been so marked as to force us to believe that the uniformitarians have overaccentuated the slow movement, through all time, of the forces now in operation. The modern geologist is forced to recognize that there have been changes—sometimes gradual and sometimes sudden—in the intensity and mode of action of existing forces. And these changes seem more and more marked as wider areas of the earth's crust have come under the scrutiny of the geologist, during the century that has not yet elapsed since Sir Charles Lyell made his epoch-marking generalization; but that does not mean that the geologist of today is in any sense swinging to the conclusions of the catastrophist. These forces bringing about elevation and subsidence are covered by the term *diastrophism.*

Vulcanism is another of the igneous agencies for the application of terrestrial energy, whose work as a harbor-maker, of little importance in the past, is destined to play an important part in the immediate future. Since our own nation has learned that the way to national power is over the waves, and our hope is that the conquests of the future will be of a commercial sort, harbors of refuge and naval harbors are now seen in a new light, as aids to commerce without which the commercial harbor can never grow into a great port. Harborage of such a sort is afforded in numerous instances where the rim of a volcanic crater has broken down in one or more places, and the whole submerged to such an extent that the central cavity forms excellent harborage, often of great strategic importance. Harbors of this kind are known in nearly all seas; but they have hitherto been dismissed with the statement that they have no other than a scientific interest, if indeed they are mentioned at all in any discussion of the subject. Fortunately, our own country owns several such harbors in different parts of the Pacific. These and coral-reef harbors, which are to be considered in some detail, afford excellent naval harbors and coaling stations, not only in the Pacific and

the Caribbean, but in other parts of the world as well, and the ownership of such harbors is a matter of immediate and strategic importance.

The classification adopted, tentatively, gives us:

I. Estuarine harbors, lagoon harbors, delta harbors, formed in the main by gradational processes, but in most cases profoundly influenced by diastrophic action.

II. Fjord harbors, moraine-enclosed harbors, indented kame-plains, all the product of glacier action.

III. Crater harbors, coral-reef harbors, and a combination of these two, in which the reef, fringing close upon the volcanic rock, has profoundly influenced the form and the commercial or strategic value of the harbor.

While the effect of organic life on harbors is generally very great, the influence of animal life is not always beneficial; and the influence of plants is almost wholly detrimental, leading to the accumulation of sediment and the consequent shoaling of water.

In determining the value of each harbor considered, the geological and other physical features of the shore; the strength, direction, range, and scour of the tides; the depth of water in the protected area; the influence of prevailing and seasonal winds; the angle at which the heaviest waves impinge on the coastline and their pounding on the headlands; the slope of the foreshore; the transportation of detritus to the basin and its deposition by the currents; and the width and shape of the entrance, have all been taken into account. Lastly, the industrial and commercial possibilities of the hinterland have often been examined into in an effort to determine whether a promising harbor might some day be developed into an important port.

Election of Members:

The following members of the faculty were elected to Active Membership in the Society: Dr. H. B. Anderson, Dr. H. W. Crane, Dr. F. C. Vilbrandt, Prof. G. M. Braune, Prof. H. F. Janda, Prof. E. L. Mackie, Mr. C. D. Beers, Mr. J. H. Bradley, Mr. J. F. Daugherty, Mr. M. A. Hill, Mr. H. F. Latshaw, Mr. G. W. Smith.

The following students were elected to Associate Membership: From the Department of *Botany*—J. N. Couch, F. A. Grant, Mrs.

W. J. Matherly; *Chemistry*—J. A. Bender, C. K. Brooks, F. C. Cochran, E. W. Constable, H. D. Crockford, E. D. Jennings, J. L. McEwen, E. O. Moehlmann, J. L. Mourane, L. V. Phillips, H. G. Pickett, W. B. Smoot; *Civil Engineering*—J. P. Clawson, L. W. Fischel, N. P. Hayes, E. M. Knox, O. E. Martin, L. J. Phipps, J. W. Taylor, J. S. Wearn; *Electrical Engineering*—G. T. Finger, J. L. Pressley, R. A. Tillmann, R. M. Wearn, D. A. Wells; *Geology*—E. J. Alexander, H. H. Bullock, R. E. L. Carson, C. W. Fowler, H. C. Harris, T. G. Murdock; *Mathematics*—J. N. Brand, W. V. Parker; *Medicine*—Howard A. Patterson; *Pharmacy*—E. B. Bristow, J. E. Campbell, W. A. Prout; *Physics*—Wade Gardner, C. G. Mauney; *Psychology*—W. D. Glenn, John H. McFadden; *Zoology*—W. L. Smith.

251st MEETING—NOVEMBER 8, 1921

F. P. VENABLE—*Isotopes.*

The growth of the idea that the atoms of the elements might be dissimilar as to their relative weight was traced through the work of Crookes and others and the revelations of radio-activity; the necessity for assigning a number of elements to the same position in the Periodic Table was pointed—hence the need of a new designation, namely, isotopes. The physical demonstration of the existence of isotopes, the determination of their atomic weight and the relative proportions in which they occurred were described, and the close agreement with accepted atomic weights noted. The paper appeared in full in this Journal, Vol. 37, p. 115.

W. C. COKER—*A Visit to Lapland and to Some Old Herbaria.*

The past summer was spent in Europe in the study of fungi in several of the most important herbaria. About a month was spent (two weeks at first and two weeks later) at Kew Gardens, England, in the use of the fine library, and in looking over plants sent by our Dr. M. A. Curtis to Rev. M. J. Berkeley. Another month, with the exception of a short trip to Lapland, was spent in Stockholm, Sweden, with daily trips by tram to the massive new Riks Museum, where are to be found several fine collections of fungi, notable among them being those of the Sydows and that of Bresadola, the latter recently bought by the well-known mycologist Lars Romell, a patent lawyer by profession and a devoted scientist by instinct, who has deposited

it at the museum and made it available for study. The Lapland trip was to Abisco, arriving on July 18, about a week too late to see the full midnight sun, but there was no darkness and the sun was visible for twenty-three hours of the day. The Laps were all living in the same primitive fashion, but some of them were well-to-do from the profits of their reindeer herds. After a few days in Copenhagen and Berlin about a week was spent at the Riks Herbarium at Leiden, Holland, where may be found the herbarium of Persoon, one of the greatest pioneers in the study of fungi. After several days study at the Herbarium of the University of Paris, at the Jardin des Plantes, where one is constantly reminded of the great Lamarck, Kew was again visited for two weeks, and the trip ended.

252nd MEETING—DECEMBER 13, 1921

A. S. WHEELER—*Research in Progress in Organic Chemistry at the University of North Carolina.*

A study is being made with Mr. I. V. Giles of the action of chlorine upon 2-amino-p-cymene. The constitution of the monochloro-derivative has been determined and a series of new dyes has been prepared by coupling it up with hydroxy compounds in the benzene and naphthalene groups. These dyes are browns and yellows, especially adapted to wool. The problem given to Mr. S. C. Smith is the constitution of the N,N′, β, β, β-Dichloro-hydroxyethylidene-bis-nitranilines, discovered some years ago by Dr. Wheeler. Mr. H. M. Taylor is engaged in determining the constitution of bromo-2-amino-p-cymene and will seek to prepare new dyes with it. Mr. F. P. Brooks is studying the complex reaction between phenylsemicarbazine and acetonylacetone, a diketone. The solution of the constitution of Oxyjuglone is in the care of Mr. A. P. Sledd. This substance was discovered 35 years ago. Mr. B. Naiman is studying the behavior of monobromo-5-hydroxy-1,4-naphthoquinone. Mr. T. P. Dawson's work concerned the addition and condensation products of chloral with 3-nitro-4-toluidine. To Mr. C. K. Brooks was given the problem of the constitution of monobromoamino-p-xylene. Dr. Wheeler is working in his own laboratory upon the reaction between phenylsemicarbazine and acetylacetone, having a grant from the Graduate School to pay the cost of the raw materials.

A. H. PATTERSON—*The Ether vs. What?*

The older theories of the ether were given, and the various theories of light described, with the reasons for and against each. The difficulties attendant upon the results of experiments of Airy, Lodge, Michelson and Morley, etc., were described, and the newer attempts to frame theories to account for all observed facts were presented: the wave theory, the ether-storing theory, the Cone-Ray theory and the Quantum theory.

Each of these was examined as to its ability or inability to explain Ionization and Photo-electric effects, Interference effects and Quantum relations. In the course of the discussion of the paper Einstein's latest views on the subject were brought out.

253rd MEETING—JANUARY 10, 1922

G. M. BRAUNE—*Experimental Determination of Lateral Earth Pressures.*

The question of finding the correct or approximately correct lateral pressures existing in masses of granular material such as earth pressures against retaining walls or grain in elevators has been studied by physicists and engineers for a great many years.

The problem as occurring most often in engineering structures is the active pressure against retaining walls. The correct determination of this force affects the design of construction work, involving the expenditure of millions of dollars yearly, and therefore a proper knowledge as to its correct magnitude is of great economic value.

C. A. Coulomb, the French physicist and engineer, was probably the first one to present a working theory for the determination of earth pressures. Rankin, the great English engineer, developed the theory on the assumption that the filling material behind the wall consisted of an incompressible homogenous granular mass of unlimited extent, without cohesion, the particles being held together by friction on each other. These assumptions lead to the ellipse of stress and make the resultant earth pressure on a vertical surface parallel to the top surface. The German engineers have also given much study to this problem and some valuable experiments have been made by Mueller-Breslau at the Charlottenberg Laboratories. In America Major William Cain has contributed more than anyone else in this country, and is considered an authority on the subject.

When the writer became connected with the University of Cincinnati some nine years ago, he decided to construct an earth pressure machine of such a size that it would reduce the effect of cohesive stresses to a minimum.

The method adopted of obtaining the magnitude of the earth pressure was to measure the horizontal and vertical components of the action of the filling material upon a "free body." In order to carry out this method a wooden wall or gate five feet wide and six feet high was constructed which fitted into the open front of a concrete bin five feet wide and nine feet long, six feet high at the front, and twelve feet high at the rear. The wall is supported by two vertical rods or contact points which rest directly upon Fairbanks' platform scales of two thousand pound capacity. Thus, any vertical force acting on the wall is directly transmitted to the scales and is registered. The horizontal thrust of the earth against the wall is measured by three horizontal struts, one at the top in the center of the width and one at each of the lower corners. These struts by rocker-arm arrangements transmit the pressure directly to platform scales of one thousand pound capacity. From the individual scale readings, the amount, direction and point of application of the resultant pressure can be computed.

Method of Operation. Before any filling material is placed in the bin the riders are run out on the scale beams so that the beams will always be down. The reading on the scales will at all times be in excess of the contemplated active earth pressures; the gate is prevented from moving into the bin by bearing angles. Then after the filling material has been placed in the bin, by moving the riders and by allowing the beam to float, we will get active and not passive pressures.

Description of Experiments. The results of the experiments made on this machine and tabulated below were made, under the direction and supervision of the writer, by Mr. Jacob Feld, a fellow in the Civil Engineering Department of the University of Cincinnati. The filling material consisted of sand weighing one hundred pounds per cubic foot. The angle of natural repose was found to be forty degrees and the angle of internal friction thirty-four degrees. The angle of friction between the sand and the dry wood of the wall was twenty-six degrees. When the wood was wet this angle increased to thirty-

one degrees. Readings were taken for every three inches of fill, the material being shovelled in horizontal layers.

The tabulated quantities of these experiments are defined as follows:

h = height of fill, feet;
P = $\sqrt{H^2 + V^2}$, total pressure per foot width;
H = horizontal component per foot width, pounds;
V = vertical component per foot width, pounds;
Φ^1 = angle of inclination of the resultant from the normal to the back of wall; $\tan \Phi^1 = V/H$;
x = height of point of application above the base of the wall = $\frac{\text{H top x 6 ft.}}{\text{H total}}$
x/h = ratio of height of the point of application of the resultant to total height of fill;
H^1 = theoretical horizontal component from formula $H = \frac{1}{2}\ wh^2\tan^2 (45° - \frac{1}{2}\ \Phi)$;
w = weight per cu. ft. of filling material;
Φ_1 = angle of natural slope (40 deg., as determined for this material);
H_2 = same as H_1 where
Φ_2 = angle of internal friction (34 deg., as determined for this material).

h	P	H	V	Φ^1		$\frac{x}{h}$	H_1	H_2
2 ft.	62 lbs.	54 lbs.	32 lbs.	30°	50′	.425	44 lbs.	56 lbs.
4	242	205	131	32°	50′	.358	174	226
6	545	464	285	31°	30′	.365	393	507

Conclusions—For this case, horizontal fill and vertical wall, the formula $H = \frac{1}{2}\ wh^2\tan^2 (45 - \frac{1}{2}\ \Phi)$ may safely be used, if Φ is taken as the angle of internal friction. For this special case, Coulomb's and Rankin's theories give the same formula.

OTTO STUHLMAN, JR.—*Theory of the Audion and its Application to the Wireless Telephone.*

Through the courtesy of the American Telegraph and Telephone Company three reels of moving pictures were shown, the first two of which illustrated the theory of the audion and the third its application to the wireless telephone.

Preliminary experiments were shown to illustrate a stream of electrons and how this same stream of electrons functioned in the case of the audion. The subsequent discussion went into details of the origin of the discovery and development of the thermionic effect and the contributions made by Richardson, his students, and the results of recent experiments on the audion as developed by the research laboratories of the great electrical manufactories of the country.

254th MEETING—FEBRUARY 14, 1922

T. F. HICKERSON—*Transition Spirals for Roads: A New Method.*

No abstract furnished.

FRANK C. VILBRANDT—*The Manufacture of Beet Sugar.*

Beet sugar, indistinguishable from cane sugar, is obtained from a variety of white beet containing from 12-19% sugar. At best, however, beet sugar factories obtain but 240 pounds of refined sugar per ton of beets sliced.

Preparations are begun nine months previous to the sugar campaign to make the ten weeks campaign successful and efficient. The agricultural staff oversee the best cultivation to insure good beets and eliminate mongrel stock. The engineering staff overhaul the entire plant and make the proper repairs and changes.

In fall the topped, matured beets are transported to the nearby factories and stored in bins or sheds in the yards. Each bin is provided with a flume which transports the dirty beets through stone, sand and trash catchers to the beet-washer. The washed beets, after elevation to a picking table to remove decayed beets, are weighed and sliced. The v-shaped slices provide for minimum settling of the cossettes, minimum rupture of the cells and maximum exposure of cell walls through which the diffusion takes place.

The cossettes are extracted in three and one-half ton batches in fourteen diffusion battery cells, three of which at any time are being filled, the others in operation. The fresh water meets the most exhausted cossettes, leaving the battery as concentrated juice in the part holding fresh cossettes. Calorizors between each battery maintain the optimum temperature for extraction.

The exhausted pulp is dumped and pumped to the pulp house where a reduction of 12% moisture is effected by means of a wet drag, pulp presses, and a furnace.

The raw juice is limed, carbonated and filtered at least two times to reduce the pulp and non-sugars by precipitation, coagulation and filtration. The juice also receives a sulfur dioxide treatment to reduce the lime content and color. Calorizors between each set of equipment maintain the optimum temperature.

This treated and purified juice is evaporated down in quintuple effect evaporators from 10% to 60% solids, treated with sulfur dioxide,

filtered and evaporated under vacuum down to grain in the "A" or "White" pan. The "strike" is then made and the mix centrifuged. The resulting "first swing" sugars are washed with steam, dried and granulated, the product being the refined white granulated beet sugar.

The first swing of molasses is evaporated to grain in the "B" or "Brown" pan and dropped into crystallizers, where for 60 to 80 hours crystal growth is permitted with agitation and slow cooling. These crystals are centrifuged from the waste molasses, redissolved and introduced into the system of refining to be evaporated down with the raw juice and recovered as white sugar.

Coöperation among the various stations is eminently important to reduce loss of sugar in wash and waste water, extraction of undesirable non-sugars and reduction of coal consumption. A loss of each 0.03% sugar in any operation in a 100,000 ton beet campaign registers a loss of 600 bags of sugar and each 3% additional quantity of water to be evaporated increases the daily consumption of coal 10 tons.

The hope is expressed that sugar beet culture and beet sugar plants may become more extensive to increase our home supply of this staple.

255th MEETING—FEBRUARY 25, 1922

DR. J. E. MILLS, Director of Chemical Research at Edgewood Arsenal.—*Chemical Warfare—Methods of Attack and Defense.* (By invitation).

A review of the development of chemical warfare was given and special mention made of the following methods:

Cylinders are used for cloud gas attacks, the cylinders being filled principally with chlorine or with mixtures of chlorine and phosgene. They are generally installed in the front line and released under suitable wind conditions. 20 tons of gas or even more will be used per 1000 yards of front for such an attack. The advantages and disadvantages of this form of attack were discussed.

Livens projectors are used and installed in special trenches, later carefully camouflaged, generally somewhat back of the front line. They fire a drum containing 30 pounds of gas and have a range of nearly a mile. Thus exceedingly high concentrations of gas can be

placed directly upon the target. It is probably the most deadly form of gas attack known. The principal gases used in Livens drums are phosgene and chlorpicrin.

The 4" Stokes mortar is used for gas, each shell carrying about 7 pounds. The rate of fire is very high, 10 rounds per minute being maintained even at night. The range is approximately 1000 yards.

All of the above weapons are used by gas troops and have the advantage over the Artillery of being able to place very high concentrations of gas upon the objective. As compared with the Artillery they have a disadvantage as regards the range of the weapon and also as to the accuracy of the weapon.

The number of gas shell used towards the end of the War was very large, amounting in some cases to 50% and even more of the total shell used. If the entire War is considered probably not much more than 5% of the total shell used were gas shell. Altogether the French filled about seventeen million gas shell. Mustard gas was by far the most effective gas used by the Artillery.

Methods of gas defense deal with personal protection, such as that afforded by the mask or by protective clothing, and with group protection, such as that afforded by gas alarms and protective dugouts. Gas protection is also sought by keeping troops fairly well apart or by abandoning gassed areas.

It is probable that the use of gas combined with aviation will greatly change methods of coast defense and naval offense.

256th MEETING—MARCH 14, 1922

H. B. ANDERSON—*Spirocheticidal Action of Arsphenamin (Salvarsan, "606").*

Spirochetes are a class of microscopical organisms which are, although placed with the Bacteria, very closely related to the Protozoa. After the discovery of *Spirocheta pallida* by Schaudinn, who at first classed it with the Protozoa, there were many experiments made to determine the spirocheticidal action of various arsenical compounds such as had been efficient in the treatment of protozoan diseases. Ehrlich discovered a synthetic organic arsenical compound which had very pronounced spirocheticidal action. This he called salvarsan. Soon after this discovery he placed neo-salvarsan on the market too. When the war broke out the allied nations took up the manu-

facture of salvarsan and in the United States is was called arsphenamin and neo-arsphenamin.

The author reports a dark field study of six cases with primary lesions and one case with secondary lesions after the administration of arsphenamin and neo-arsphenamin. Six of these cases showed an absence of live spirochetes in the lesions 48 hours after the administration of the drug. One seemed more refractory to arsphenamin and did not show complete sterility of the lesion for 8 days after the administration of the drug.

J. F. DASHIELL—*Measurement of Intelligence in Different Social Classes.*

After preliminary discussion of intelligence and its measurement, and of the correlation of economic class differences with certain physical and mental traits, a brief experimental study was reported. In continuation of a study made four years earlier by Chase and Carpenter, Dashiell and Glenn made Binet intelligence examinations of Chapel Hill children belonging to different social-economic groups. The same results were found: a correlation between economic class and intelligence level: the country, town, and faculty children showing respectively low, medium, and high levels. To make sure that previous conditions of literacy in the children's life played no part, a series of motor performance tests was given the same subjects. Results for the faculty group were still distinctly high, but the country children now excelled the town children slightly. Thus, the Chapel Hill school population appears divisible into two groups on the basis of hereditary family stock, with a subdivision of one of these on the basis of environmental opportunity.

257th MEETING—APRIL 11, 1922

ARCHIBALD HENDERSON—*Generalized Relativity and the Three Tests.*

The Newton and Einstein cosmologies were compared in detail, using the device of parallel columns. The author then outlined the trend of Einstein's thought in reaching his epochal generalization, and showed how the transition was made from the Restricted to the Generalized Relativity. In especial, he described the practical mode by which Einstein's theory was tested, and indicated the procedure employed in making these tests. In particular he announced that news he had just received from Paris that the third test,—the shift

toward the red end of the spectrum of rays of light emanating from the sun,—had been conclusively established to a very close degree of approximation by the eminent French physicist Pérot.

W. F. PROUTY—*The Rejuvenated Ocoee.*

J. M. Safford of Tennessee, described the Ocoee in 1856. He then classed it as "Metamorphic" and considered it of Pre-Cambrian age, but in his report of 1869 he placed this group in the Potsdam (Cambrian). Arthur Keith after careful study of the western portion of the Ocoee of Tennessee and North Carolina, confirmed Safford's correlation for the western portion and, like Safford, placed the entire group in the Cambrian.

In 1903 Dr. E. A. Smith of Alabama discovered fossils in the eastern portion of the Ocoee of that State. These were determined by David White to be of Carboniferous age. The working out of the relationship of this fossiliferous area to the rest of the Ocoee recently fell to the author in the study of Clay County, Alabama. A careful study of the structure of the area brings out the fact that a considerable portion at least of the Ocoee is of Carboniferous age, both Mississippian and Pennsylvanian being represented.

At the present time therefore it is known that the Ocoee Group consists of at least three systems of rocks.

258th MEETING—MAY 9, 1922

WM. DEB. MACNIDER—*The Changes Induced in the Kidney by the Continued Use of Alcohol.*

Dogs were employed in the experiments. The animals were given 10cc. of 20 per cent alcohol once a day to the point of establishing a moderate grade of intoxication. Such a state was shown by muscular incoördination and drowsiness.

Following such a usage of alcohol the animals develop in from seven to eighteen days a well-marked albuminuria. The number of tube casts in the urine are few as compared with the quantitative output of albumin. There is but a slight reduction in the elimination of phenolsulphonephthalein. Kidneys from such animals show but slight injury to the tubular epithelium. The glomerular capillaries show an early and very marked accumulation of stainable lipoid in the endothelium.

H. V. WILSON—*Metschnikoff, Zoologist and Pathologist.*

Elie Metschnikoff (1845-1916) is doubly distinguished in that he brought to light a great idea in abstract science and himself carried it over and further developed it in a field that is directly concerned with the physical welfare of mankind. In the course of Metschnikoff's many, varied, and eminently original studies on the comparative embryology of invertebrates, ending with his "Embryologische Studien an Medusen" (Wien, 1886), his attention was focussed again and again on the wandering, amoeboid cells, which play so important a part in the development and physiology of sponges, coelenterates, echinoderms and other invertebrates. Correlating the wandering, digestive, and protective (Messina, 1882) functions of such cells, he asked himself if the leucocytes of vertebrates were not essentially similar elements. With this began his famous discoveries in Pathology concerning the direct and indirect action of leucocytes against invading bacteria.

ELECTION OF OFFICERS:

President—W. F. Prouty.
Vice-President—Otto Stuhlman.
Permanent Secretary—J. M. Bell.
Recording Secretary and Treasurer—H. R. Totten.
Editorial Committee—W. C. Coker, chairman; J. M. Bell, Collier Cobb.

CALLED MEETING—JUNE 2, 1922

A meeting was called to consider some appropriate action in recognition of the late Charles Baskerville. A motion was passed that the next number of the JOURNAL of the Elisha Mitchell Scientific Society (Vol. 38, Nos. 1 & 2) be dedicated to his memory.

THE SEARCH FOR THE ULTIMATE ATOM*

By J. L. Lake

Just when the belief in a primordial atom originated in the mind of man seems difficult to determine. Sometimes it seems like a primal notion. The Encyclopedia Britannica tells us, "The concept of an element as a substance from which all bodies are made or derived was held at the very beginning of occidental philosophy." We are also told that Thales of Miletus, who immortalized himself by recording the fact that rubbed amber would attract light bodies, regarded water as the element of all things, and that his followers accepted his ideas of a primordial substance as the basis of all bodies but that they endeavored to determine some other general elements.

Democritus is regarded as the founder of the atomic theory though we are told that traces of the conception of the grained structure of matter are to be found in Indian philosophy perhaps twelve centuries before the Christian era. As Millikan says of the principles of Democritus as given by Tyndall, with a few modifications and omissions they might almost pass muster today. Yet though his theory was advocated by Epicurus and the Latin poet, Lucretius, the Platonic school prevailed, and, as we know, the Aristotelian philosophy dominated the world of science as well as philosophy till the seventeenth century.

In the time of Boyle and Newton, however, an atomic theory reappeared. We know how forcefully Newton maintained the corpuscular theory of light. He also regarded gases as consisting of small separate particles which repelled one another, and attributed to this supposed repulsion between the particles the tendency of gases to expand. It was Dalton, however, who resurrected the atomic theory and made it a scientific hypothesis to explain experimentally determined facts instead of mere speculation. This was about 1803. Soon after this Prout published his hypothesis—that hydrogen is the primordial atom, that the atoms of all heavier chemical elements are built up from it. Von Meyer in his History of Chemistry (1891) speaks of the baneful effects of Prout's hypothesis. He states the

* Presidential address before the N. C. Academy of Science, May 5, 1922.

hypothesis as follows: "Hydrogen may be regarded as a primary matter from which all other elements are formed by various condensations." Were he stating the present day belief it is doubtful if he could improve on the statement.

Prout's hypothesis, however, was based upon inexact determinations and was unable to stand against the more exact work of Berzelius, Stas, and others. But despite the downfall of this hypothesis the germ idea, the belief in a fundamental, basal substance persisted. Von Meyer says that Prout's hypothesis acted for a long time like a ferment, in that it gave rise to continually renewed speculation upon the connection which existed between the elements and their atomic weights. May it not be that the working of this ferment finally produced the periodic tables of Newlands and Mendeleef? Moreover, does not the table of Mendeleef itself suggest that the various elements are complex and not simple? We know that Mendeleef predicted the discovery of elements to fill certain blanks in his table, and that because of their positions in the table he predicted both their chemical and physical properties. Was not the simple statement of the periodic law, that the properties of an element are periodic functions of its atomic weight, sufficient to warrant the belief in an elemental substance?

The beginning of the new era, which has been so rich in results in the search for the primordial atom, may be said to have its origin in the invention of the Crookes tube. The study of gaseous conduction has been a most interesting one for physicists from the time of Faraday in the hope that it might reveal the nature of electricity. With the advent of the Crookes tube the discharge from the negative electrode, the cathode rays, assumed chief importance. While notable work was done by many with these tubes preëminence belongs to Sir William Crookes, both for results obtained and for the interpretation of these results.

Crookes showed that the cathode rays were deflected by a magnet as if they were negatively charged particles. That they are such was first shown by Perrin and later rigorously by J. J. Thomson. From his studies of these cathode rays Crookes was led to announce his theory of radiant matter or fourth state of matter, which theory no less an authority than the Encyclopedia Britannica says led to the modern electronic theory.

Crookes's studies with the tube which bears his name extended

over a good many years. In 1883 he began the study of the nature and constitution of the rare earths. From his studies of the spectra of yttrium he concluded that there was an actual splitting up of the yttrium into more elementary substances, also he formulated the hypothesis that all the elements have resulted from a primary substance which he termed protyle.

Not only directly but also indirectly was the Crookes tube a potent factor in the establishment of the electronic theory. It was while working with a Crookes tube in 1895 that Roentgen discovered the X-rays which have been so efficient as an aid in establishing this theory. Becquerel was impressed with the similarity in appearance of the phosphorescence produced by X-rays on the glass of the vacuum tube and the phosphorescence produced in some ordinary substances by sunlight.

He thought that possibly these would emit radiations similar to X-rays. Prompted by this idea, in 1896 a few months after the discovery of X-rays he placed several substances wrapped in paper beneath a photographic plate. Of these the only one that acted on the plate was a salt of uranium. He subsequently found that this property of affecting a photographic plate was common to all the salts of uranium and that it was possessed by the element itself. Moreover, he found that this action was a spontaneous one, that it made no difference whether uranium and its compounds were exposed to sunlight or kept wholly in the dark. This was the beginning of radioactivity and the study of radioactive substance. In this study there have been numerous investigators. Becquerel extended his studies further and later found the ratio of $\frac{e}{m}$ for the beta (β) rays of radium and also their velocity. The ratio of $\frac{e}{m}$ he found practically the same as that previously determined by J. J. Thomson for cathode rays. He found, however, that they had varying velocities some moving much faster than others. These differences in the velocities of the beta (β) rays furnished Kaufmann an opportunity to test the electromagnetic theory of mass—that the mass of an electron is due, wholly or in part, to the fact that the electric charge is in motion. The findings of Kaufmann were entirely in harmony with the theory, since $\frac{e}{m}$ decreased as the speed increased.

The most notable workers in the field of radioactivity have been the Curies and Sir Ernest Rutherford. The Curies examined a great many elements and their compounds to see whether they had the radioactive property of uranium. Thorium was the only element that was found to show the effect in a degree comparable to that of uranium. They found that all minerals containing uranium or thorium were radioactive but that several specimens of the uranium ore, pitchblende, were several times more active than uranium itself. Hence they concluded that pitchblende contained some unknown substance or substances which were the cause of this activity. Inspired by this idea they sought for them in pitchblende, using chemical methods. In 1898 their efforts were rewarded by the discovery of two, which they named polonium and radium, each of which is vastly more radioactive than their common parent uranium.

The story of the successive steps by which the Curies were finally led to the discovery of these new elements Fleming characterizes "one of the most fascinating chapters in the history of science."

In 1899 Rutherford showed that the radiation from uranium was complex and consisted of rays easily absorbed, which he called alpha (α), and more penetrating rays which he called beta (β). The beta (β) rays have been thoroughly studied. While their velocities are different for different sources and in the case of radium, as already noted, the particles have unequal velocities, in general their velocities are greater than the velocities observed for electrons set free in vacuum tubes. The swiftest moving beta (β) particles have a velocity closely approaching that of light; but that they are electrons, similar in all respects to the electrons set free in a vacuum tube save in velocity alone, seems to be indisputable.

Rutherford made a thorough study of the alpha (α) particles. He showed first that they carried positive charges. Then he determined the $\frac{e}{m}$ ratio for them and showed that this was only one-half the $\frac{e}{m}$ ratio for hydrogen got in electrolysis. Under the assumption of equal charges for the alpha (α) particles and the hydrogen ions, the mass of the alpha (α) particle would be twice that of the hydrogen ion; but under the assumption of twice the charge, the mass would be four times that of the hydrogen ion. In a classical experiment in which every precaution was taken to eliminate any

misinterpretation of results Rutherford proved that the spectrum of the alpha (α) particles was the spectrum of helium. Thus he clearly demonstrated that alpha (α) particles are helium atoms which have lost two electrons.

While still somewhat removed from a complete theory of atomic structure, we can assert with positiveness that the atom is a structure and, in the case of the heavy atoms, a decidedly complicated one. For the light it has thrown on the nature of this structure the radioactive compounds have been an invaluable aid. The enormous velocities with which alpha (α) and beta (β) particles are ejected from the nucleus shows the atom is a vast store-house of energy. That the thirty odd radioactive substances are the disintegration products of uranium and thorium, that they are in a constant state of disintegration by virtue of forces within the atom, and that lead is the final product of disintegration seems now the general conclusion from experimental data.

The earliest determination of $\frac{e}{m}$ was made in 1897 by J. J. Thomson and Wiechert independently. Thomson's first determination was for the cathode rays, which Crookes claimed to be negatively charged particles. He extended his investigations to the negative ions given off by metal plates when exposed to ultra-violet light, also to the negative ions produced by an incandescent carbon-filament in an atmosphere of hydrogen. He found that the value of $\frac{e}{m}$ for these was the same in all cases, that it was a constant quantity independent of the nature of the gas from which they were produced and of the means used to produce them. These were epoch-making experiments in the development of the present atomic theory. It was with amazement the rank and file of us learned from Thomson that he had discovered corpuscles whose mass was not greater than one thousandth that of the hydrogen atom. The first estimate was subsequently revised by him to about one eighteen hundredth the hydrogen atom. Bucherer's value, now considered the most accurate, makes the mass of the hydrogen atom 1845 times that of the electron, Thomson's corpuscle. These experiments of Thomson's were followed by many others, some performed by himself, others by his pupils, in the development of the electronic theory. In the development of this theory the leading rôle has clearly been played by the Cavendish laboratory,

presided over formerly by him and now by his former pupil, Sir Ernest Rutherford. Among experiments performed by Thomson was one on the canal or positive rays, to which we shall have occasion to refer later. We may note in passing, however, that while for cathode rays whose velocity does not approach that of light he found $\frac{e}{m}$ equal to 1.7×10^8, for the positive rays the greatest value observed was 10^4, which is also the value for the hydrogen ions in electrolysis, thus reënforcing conclusions as to the relative size of the electron.

A series of experiments was performed in the Cavendish laboratory, both by Thomson and his pupils, to determine the value of e, the charge carried by the electron. The value of this most important physical constant has been determined by Millikan in a series of admirably planned and accurately executed experiments which extended over several years. His method was an important modification of one of the Cavendish laboratory experiments. His findings were very concordant, and are accurate to 0.07 of 1 per cent; the value obtained by him is now the generally accepted one.

Rutherford and Geiger devised an electrical method by which they could count the number of alpha (α) particles emitted per second by radium. By measuring the charge on the counted number they found that each alpha (α) particle carried two positive electronic units of charge, a finding in harmony with Rutherford's spectroscopic work, which showed that alpha (α) particles were helium ions. Making use of the rate of emission of alpha (α) particles by radium, Rutherford in 1911, with the aid of Geiger and Marsden, performed another important experiment. He computed the chance that an alpha (α) particle in being shot through thin sheets of gold and other metal foils would suffer a given deflection because of the positive nuclei of these metals. Most of the alpha (α) particles in passing through the foils move in straight lines but some are deviated. Rutherford's theory was that whenever an alpha (α) particle passes sufficiently near the nucleus it will be deflected by the charge of the nucleus and be deviated. The experiment involved finding what fraction of the alpha (α) particles, which were shot through the foils, produced scintillation on a screen at a position which corresponded to the computed angle of deflection. From calculations based on this experiment he concluded that the number of

positive electronic charges on the nucleus equals approximately half the atomic weight. This was the first experimental determination of atomic numbers. The rigorous and exact determination of atomic numbers, however, is the work of Mosley. Millikan has characterized his work as one of the most notable pieces of research in the last fifty years. In his work Mosley made use of X-rays and the crystal grating.

Barkla had previously discovered that when different elements were used as the anti-cathode each gave off X-rays characteristic of the element used. The Braggs had shown that crystals, because of the regular spacing of their molecules, could be used as reflection gratings for X-rays, and that by knowing the distance between the molecular planes and the inclination of the rays to the planes the wave-lengths of the rays could be determined.

Beginning with Al and using the K rays Mosley examined the X-ray spectra of most of the heavier elements. He found that in passing from the lighter to the heavier elements there was a progressive shortening of their wave-lengths, or an increase in their frequencies. The functional relation established by Mosley between frequency and atomic number is accurate to the degree that when the X-ray spectrum of any element is known its atomic number can be determined unequivocally. The work of Mosley has been extended by De Broglie and others with modifications of the Mosley method. While no X-ray spectra for the ten elements below Na have yet been obtained the properties of these elements are so well known we may confidently rely on the correctness of the numbers assigned them.

Since the table starts with hydrogen, 1, and ends with uranium, 92, with six blanks, it seems that the total number of elements is 92 and that six of these are yet to be discovered.

Not only did Mosley's work substitute a scientifically determined table for the empirical table of Mendeleef, but he proved for the first time that the physical and chemical properties of an element depend upon the nuclear charge. The logical inference from his work appears to be that each element differs from the next lower by the addition of a definite amount of electricity to the nucleus and that this addition causes a corresponding increase in the frequency of the characteristic radiation.

As the result of the experimental determinations of Thomson and others the hydrogen ion is considered to be the proton, or positive

unit of electricity. In view of the comparative masses of it and the electron the atomic weight of an element is considered numerically equal to the number of protons in its nucleus. The atomic weight of helium is 4. Since its nucleus has been shown by Rutherford to be the alpha (a) particle it contains 4 protons. While it has been proven by Aston that the mass of the helium atom is not exactly four times that of the hydrogen atom, this loss of mass, due to the packing effect, is in harmony with the electromagnetic theory of mass. That the electromagnetic theory is true, and that the mass of electron is wholly electrical, seem established by the experimental findings of various workers with the beta (β) particles of radium, whose velocities range from 0.3 the velocity of light to approximate equality. While it has been impossible to apply the same test, variation of mass with velocity, to the slower moving positive charges, it seems illogical to assume for them another explanation of mass.

The atomic member, however, is determined by the excess of protons over electrons in the nucleus. Hence we see that atomic structures may have equal atomic numbers and unequal atomic masses. Such bodies were discovered by Rutherford and Soddy in their study of the radioactive substances and were named by Soddy isotopes.

Since the chemical and practically all the physical properties of the atom are determined by its atomic number, isotopes cannot be separated by chemical methods. The most effective means of separating them has been the positive ray method, first devised by Thomson and afterwards modified and improved by Aston. In view of the recent lectures here by the last named it is needless for me to speak of his method further than to say the determinations from his mass-spectra have a very high degree of accuracy. However, I hope I may be pardoned for a few remarks about these recently discovered structures despite the lectures of the distinguished visitor and notwithstanding the illuminating paper recently presented before the Elisha Mitchell Society by a distinguished authority in chemistry.

Many, at least, of the fractional atomic weights can be explained by the presence of isotopes. Neon, with atomic weight 20.2, has two isotopes of mass 20 and 22. The atomic weight can be explained by the assumption of its having these isotopes in the ratio of 9 to 1 respectively. Magnesium with its two isotopes, 24 and 25, and the atomic weight 24.32 can be explained by assuming a ratio of 17 to 8 for the isotopes.

If we write our old friend calomel Hg_2Cl_2, as our chemical friends tell us we should, then since Cl has two isotopes and Hg has six there is a total of 63 ways in which they can combine. Whether Cl and Hg avail themselves of all their privileges I leave it to others to decide. Also whether the physiological effects of the different combinations of isotopes are identical I leave to our biological friends to determine.

Various theories have been advanced as to the grouping of protons and electrons in atomic structures. That the nucleus, save in the case of hydrogen alone, contains both protons and electrons with protons in excess, and that around this nucleus are grouped electrons equal in number to the excess of protons in the nucleus, seem now to be agreed upon by all. From Rutherford's experiment on the scattering of alpha (a) particles the radius of the nucleus appears to be of the order of 10^{-13} of a cm., while the radius of the atom is of the order of 10^{-8} of a cm. Hence the electrons constitute what may be termed a planetary system, with the positive nucleus as the central sun.

Of the theories advanced for the arrangement and behavior of electrons which will explain the chemical and physical properties of atoms, two are of commanding importance.

The Bohr atom, apparently the outgrowth of the atoms of Thomson and Rutherford, was designed primarily to explain the hydrogen atom and the Balmer or visible series of the hydrogen spectrum. The fundamental assumption of Bohr, that the electrons rotate around the nucleus in non-radiating orbits, or that an electron loses no energy while it remains in the same orbit, is in harmony with our theory of magnetism and furnishes a satisfactory explanation of the stability of the hydrogen atom. The law of force assumed by Bohr for the electrons rotating in these non-radiating circular orbits is simply the Newtonian law for planetary motion.

The second assumption of Bohr was that radiation takes place only when an electron passes or jumps from a larger to a smaller orbit. He assumed that the energy lost in this change is proportional to the frequency, that it is always one quantum.

In his energy equation to determine the possible orbits for the electron Planck's constant is again involved. The equation involves this constant, the orbital frequency of the electron and an integer; the equation is so framed as to make the series of frequencies agree with the Balmer series of hydrogen.

That the Lyman series for hydrogen is in accord with the Bohr atom, although Bohr announced his atom before the series was discovered, is not remarkable; but the very close agreement between the experimentally determined value of the constant in the Balmer series and the value of this constant, computed by the Bohr theory, is a fact of significance. Numerous other physical facts are in harmony with the Bohr theory. Whether this theory can be so modified as to furnish a complete explanation of physical and chemical facts remains to be seen.

The Lewis-Langmuir atom, proposed by Lewis and developed greatly by Langmuir, is discussed at length by Langmuir in the June number of the *Journal of the American Chemical Society*, for the year 1919. As in the construction of the Bohr atom the predominant idea was the explanation of physical phenomena, so in the Langmuir atom the predominant idea was the explanation of chemical phenomena. The guiding principle in this construction seems to have been that a system in unstable equilibrium tends to pass into one of stable equilibrium. Adopting an untechnical classification of the chemical element suggested by Mills, we may classify the elements as satisfied, unsatisfied, and dissatisfied. The radioactive elements, which by ejecting alpha (α) and beta (β) particles are constantly changing into other elements and finally end in lead, constitute the dissatisfied. The inert gases constitute the satisfied although the degree of satisfaction wanes as we pass from helium to niton. The atoms between the satisfied constitute the unsatisfied and hence are chemically active.

Between neon, atomic number 10, and argon, atomic number 18, lie the seven elements Na, Mg, Al, Si, P, S, Cl. The first three of these give up electrons and are electropositive, the last three take electrons and are electronegative, while Si, midway between the two, avails itself of its double privilege and is sometimes electropositive and sometimes electronegative.

The Rydberg formula for the atomic numbers of the inert gases is $N = 2\ (1 + 2^2 + 2^2 + 3^2 + 3^2 + 4^2)$. In the construction of his shells Langmuir states he was guided by this formula. Passing through the nucleus of the atom is a plane of symmetry which Langmuir terms the equatorial plane. No electrons lie in this plane. His shells, on which lie the external electrons, are approximately spherical. The first is for helium and its radius is taken as unity. One electron is in each of the hemispherical surfaces called a cell. The elec-

tron can vibrate or oscillate in this cell but cannot depart from it. The second shell has a radius of two and hence four times the area of the first. Since all the cells are equal in area this has a capacity for 8 electrons, 4 in each hemisphere, and we have the shell for neon. Superposed on this shell is another of approximately equal radius and hence of equal capacity. This is the shell of argon. The next two shells, one superposed upon the other, have the radius 3, hence each can contain 18 electrons and we have the shells for krypton and xenon. The next shell with a radius of 4 accommodates 32 electrons and gives us the shell for niton.

There can be no electrons in the outer shell till the inner ones are completely filled. The atoms with the partially filled shells constitute the active elements. The tendency of these outside electrons to combine so as to form stable configurations constitutes chemical action. Quoting from a brief article by Langmuir: "The 8 electrons in the second and third layers are arranged in a symmetrical way like the arrangement of the 8 corners of a cube. This stable group of 8 electrons is called the Octet. The chemical properties of the elements result from the tendency of the individual atoms to take up or give up electrons in order to form Octets."

This theory has been highly successful in explaining chemical phenomena and, says Langmuir, "has made it possible to predict correctly the properties of certain substances before these properties have been determined by experiments."

The real atom must necessarily incorporate whatever is true in both the Bohr and Langmuir atoms. It seems that in all probability it may be a compromise between the two.

WAKE FOREST, N. C.

TWENTY YEARS OF THE NORTH CAROLINA ACADEMY OF SCIENCE

By C. S. Brimley

With this meeting (that of 1922), the North Carolina Academy of Science closes its twentieth year, and at the request of the secretary, Dr. Cunningham, I have prepared a brief review of those first twenty years of its history.

No account of its origin has ever been published, the first printed records being those of the first regular meeting for the presentation of papers at which time the Academy had already been organized for over six months.

The manner of its beginning was in this fashion. W. W. Ashe, at that time State Forester, conceived the idea of organizing such an institution for the State sometime in 1901, and he communicated his thoughts to Franklin Sherman, State Entomologist, and H. H. Brimley, Curator of the State Museum, and later on to F. L. Stevens, Plant Pathologist at the A. and M. College, and Tait Butler, State Veterinarian. These five gentlemen held various conferences and discussions, and the idea also spread among the members of the Raleigh Biological Society of which Dr. Stevens was president. This was mainly during the early part of 1902.

Finally these five gentlemen sent out a call for a meeting to organize a North Carolina Academy of Science, though I am not sure whether the call was signed by others or by these five gentlemen alone, nor do I remember just to whom the appeal was sent. Probably it went mostly to biologists as all the gentlemen interested were biologists themselves, and I have a dim recollection of some discussion as to whether the attempt should be to form an Academy of Science or of Natural Sciences. The former was finally decided upon, but I am not at all sure that that decision was reached before the call was sent out.

However, be that as it may, the call was sent and in response to it there assembled in Dr. Butler's office in the State Agricultural Building at Raleigh on March 21, 1902, four of the five originators (Sherman, H. H. Brimley, Stevens, and Ashe), Dr. Butler being out

of town at the time, and five others, namely: W. L. Poteat, Professor of Biology at Wake Forest College, T. Gilbert Pearson of Guilford College, B. W. Kilgore, State Chemist, J. L. Kesler, Professor of Science at the Baptist Female University (now Meredith College), and the writer.

Dr. Stevens presided till the permanent officers were elected and Mr. Sherman acted as secretary. Two sessions were held, one in the afternoon and one at night. After much discussion it was agreed to go ahead with the organization of an Academy of Science, although there was a doubt in the minds of some as to whether it might not be advisable to wait until a larger representation of the scientists of the State could be secured. The majority, however, feared that any delay might prove to be permanent and it was decided to proceed and organize the Academy at that meeting.

Consequently the North Carolina Academy of Science was organized then and there with a constitution, a full set of officers and twelve charter members. The charter members were the five originators (Ashe, H. H. Brimley, Sherman, Stevens, and Butler), the others present at the meeting (Poteat, Pearson, Kilgore, Kesler, and I), and two others (Dr. H. A. Royster of Raleigh, and Dr. H. V. Wilson, Professor of Zoology at the University). Of the twelve charter members, six have retained their membership to the present time, the others having with one exception left the State. The first officers were: W. L. Poteat, President, T. G. Pearson, Vice-President, Franklin Sherman, Secretary. An executive committee was also elected, consisting of nine members, including the president and secretary. It may be added that at first there was some idea that the Academy was intended by its founders to be a Raleigh institution and for some three or four years the majority of the executive committee was from Raleigh as also were the first two secretaries. However no such idea was present in the minds of the charter members and with the election of Dr. Gudger as secretary in 1907 it finally sank into oblivion.

I should be inclined at this distance of time to give a larger part of the credit for the success of the organization meeting to Messrs. Poteat, Sherman, and Stevens, than to the other members, although I know it is somewhat invidious to discriminate in such matters.

Twenty regular meetings for the presentation of papers have

been held since that memorable day, the first two in the fall, the others in the spring.

Twenty-one presidents have held office, namely: W. L. Poteat (Wake Forest College, Zoology), C. W. Edwards (Trinity, Physics), Charles Baskerville (University, Chemistry), F. L. Stevens (A. and M. College, Botany), J. F. Lanneau (Wake Forest, Astronomy), Collier Cobb (University, Geology), T. Gilbert Pearson (State Normal, Ornithology), Tait Butler (Agricultural Department, Veterinarian), W. C. Coker (University, Botany), W. H. Pegram (Trinity, Chemistry), H. V. Wilson (University, Zoology), C. S. Brimley (Raleigh, Zoology), Franklin Sherman (Agricultural Department, Entomology), J. J. Wolfe (Trinity, Botany), A. S. Wheeler (University, Chemistry), F. P. Venable (University, Chemistry), W. A. Withers (A. and M. College, Chemistry), E. W. Gudger (State Normal, Zoology), A. H. Patterson (University, Physics), Z. P. Metcalf (State College, Entomology), J. L. Lake (Wake Forest, Physics).

It will be seen from this list that the University contributed 7 presidents, Trinity, Wake Forest and the State College, three each, the State Agricultural Department and the State Normal College, two each, and private life one. As to the branches of science represented there were seven chemists representing both organic and inorganic chemistry, seven zoologists, (including two entomologists and one ornithologist,) three each botanists and physicists, one astronomer, one geologist, and one veterinarian.

The place of meeting has from the first rotated between Trinity College, Wake Forest College, State College, the University and the State Normal (now the North Carolina College for Women) usually in the order named, there having been five meetings at the State College, three at the State Normal and four at each of the other institutions.

The proximity of these five institutions of learning, united to the fact that the State Department of Agriculture, Elon College, Guilford College, and several other smaller institutions fall within the same area, is one of the causes that made the existence of a successful Academy of Science an accomplished fact in North Carolina. I do not wish to minimize the work of those who organized the Academy nor of those who have successfully piloted it through its twenty years of existence, but if these institutions had been scattered all over the

State their work would have been much harder and might not have succeeded.

The first meeting at Trinity College was quite a success but the second at the University (in the fall of 1903) was rather a frost, only two persons outside of the University, the president, Dr. Edwards, and I being in evidence on the first day of the meeting, though a few more turned up next day. Even the secretary was away in Texas attending a cotton boll weevil meeting or convention. Nevertheless the meeting was by no means a failure and the successful meeting at Wake Forest next spring dispelled all doubts as to the success of the Academy.

During its early years, in fact up to 1910, the membership of the Academy averaged about forty to fifty, but in that year an intensive campaign for new members was put on and the membership doubled. Since then the membership has oscillated between seventy and eighty but in the last two years has gone well over a hundred and shows signs of never again dropping below that number. It may be noted here that the campaign for membership was incited by the uneasiness of our esteemed secretary, Dr. Gudger, who was easily depressed by a slight drop in the Academy's bank balance, which, however, never at any time got dangerously low.

Of the Academy's hard working secretaries (Franklin Sherman, 1902-1905, F. L. Stevens, 1905-7, E. W. Gudger, 1907-1918, Bert Cunningham, 1918-1919, and 1921-....., and R. W. Leiby, 1919-1921), two deserve especial mention, Mr. Sherman who piloted the Academy through its first perilous years, and Dr. Gudger who for eleven years faithfully sat at the receipt of custom, always with a genial smile, always on the job, and always with a nice little balance to the Academy's credit, though its occasional downward trend invariably disturbed his equanimity for the time being. His departure from the state was a great loss and he will long be missed by his old associates.

In its course of existence the Academy has lost quite a number of its prominent members, a few by death, more by removal from the state. Thus Mr. Ashe and Professor Kesler left the state very soon after its organization, Messrs. Stevens, Butler, Baskerville, Pearson, and Gudger, each shortly after the expiration of his presidential term. Dr. J. J. Wolfe and Dr. J. S. Lanneau, both ex-presidents and both sturdy pillars of the Academy, as well as Dr. Baskerville have died within the past three years.

Among those who have been more conspicuous in the Academy the following deserve notice: Charles Baskerville, H. V. Wilson, W. C. Coker, Collier Cobb, A. H. Patterson, and A. S. Wheeler of the University; C. W. Edwards, J. J. Wolfe, and Bert Cunningham of Trinity; W. L. Poteat, J. S. Lanneau, and J. L. Lake of Wake Forest; T. Gilbert Pearson and E. W. Gudger of the State Normal; F. L. Stevens, W. A. Withers, and Z. P. Metcalf of the State College; Franklin Sherman, Tait Butler and R. W. Leiby of the State Agricultural Department.

In 1904 the annual meeting was held in conjunction with the spring meeting of the North Carolina section of the American Chemical Society, largely through the efforts of Dr. Baskerville, and the arrangement has proved so acceptable to both organizations that it has been continued, with an occasional lapse, ever since.

"Behold the field that seemed barren,
How great a harvest have the years revealed."

RALEIGH, N. C.

SOME PHASES IN THE DEVELOPMENT OF CHRYSEMYS CINEREA*

By Bert Cunningham

Plates 2-4

Introduction

The egg production, egg-laying habits, nest building, and the development of the embryo through the gastrulation stage in *Chrysemys cinerea* are dealt with in this paper. A satisfactory method of artificially incubating the eggs has made it possible to secure consecutive stages of development in such numbers that careful study could be made of many points which have caused dispute.

Many details of turtle embryology have been worked out, but there has been little collection or unification of these data. Since several forms of turtles were used by the various writers, it will be impossible to limit the discussion of the literature to even a single genus, and the contradictory opinions of these writers as to developmental history probably resulted from the uses of a variety of forms.

As early as 1828 Tiedmann published a report upon two eggs of *Emys amazoni.* This was followed by the description (exact title unknown) of a turtle egg seven days old by Carus in February, 1829. In the same year Berthold discussed the absence of the chalaza in the egg of *Emys.* An account of a young egg of *Emys europaea* was published by Von Baer in 1834. Three years later he published "Ueber Entwicklungsgeschichte der Thiere," Teil II, in which he points out the similarity of structure of the eggs of the chick and the turtle, and the greater time required for the development of the latter. His conclusions were based upon the observations of Carus and Tiedmann. He noted also that while the ovary and oviduct of the chick is single, that of the turtle is paired. Peters (1838) published an article upon a young "Schildkroete." Rathke, who is often credited with the first embryological work on Chelonians, began his contributions to embryology in 1832 with an account of the "Wolffscher"

* The writer wishes to express his appreciation to the Zoological Staff of the University of Wisconsin, especially to Dr. E. A. Smith, Dr. M. F. Guyer, and Dr. A. S. Pearse for helpful suggestions and criticisms.

bodies of the turtle. The results of his later investigation were published (1848) under the title "Entwicklung der Schildkroeten." In this work he deals chiefly with gross anatomy of various stages of development, especially of the muscles, the carapace, and the alimentary canal.

Nothing more of importance appeared on this subject until 1857 when the classic work of Agassiz was published, which, according to Davenport (1898), "stands today with its many unverified facts as an incentive to the reptilian embryologist." Since Agassiz's time no one has attempted to work completely over the field of turtle embryology, although numerous short articles have been written.

THE COLLECTION OF MATERIAL

The materials used in the preparation of this paper were collected in the vicinity of Madison, Wisconsin. The territory around Lake Wingra furnished most of the specimens taken on land. Collections were made also on Lake Mendota, Lake Monona and on Mud Lake. A number of turtles were taken from high land, since the object was to capture them when nest building, but the majority were caught with dip nets in the water.

There seems to be considerable confusion as to the synonymy of four of the so-called "species" of *Chrysemys*, viz. *Chrysemys marginata* Agassiz; *C. bellii* Gray; *C. cinerea* Bonnaterre; and *C. picta* Hermann. *Chrysemys cinerea* was named by Bonnaterre probably between 1790 and 1800. *Chrysemys bellii* was named by Gray early in the nineteenth century, while *C. picta* was designated as *Testudo picta* by Hermann before 1792.

Agassiz recognized the validity of all four species. His differentiation, however, was built largely upon the color pattern which may easily be shown to be a false basis. In his description he indicates that the arrangement of the vertebral plates in *C. picta* differentiates it from all other forms. While some of his figures bear out this idea, the others do not. An examination of figures 1 to 6 will make this clear. Figure 2 is *C. marginata* while all the other are *C. picta*. The similarity of figures 2 and 5 is so striking in regard to vertebral plate arrangement that no one would think of making them into two species. Figures 1, 3, and 5 seem to form a graded series from the typical *C. picta* to the typical *C. marginata*.

Gadow's (1901) figure of *C. picta* (figure 7), is intermediate be-

tween figures 1 and 2. Hegner (1916) copies Gadow's figure. Ditmars (1914) says of *C. marginata* "size and structure of the shell, like the preceding (i e., *C. picta*), differs only in coloration." If color pattern were the only difference this form could well be grouped as a variety of *C. cinerea* as will be shown later. However, in his text descriptions Ditmars has overlooked the most characteristic difference shown in his drawings, (figs. 8 and 9) namely, that in *C. marginata* the neural scutes alternate with the costal. This is not true in *C. picta*. Since there was no opportunity to examine a large number of specimens on this point, it is assumed that this arrangement of the vertebral plates as indicated by Hermann (see figure 14) is sufficient to separate *C. picta* from the other species, and that *C. picta* is best represented by this figure.

Of the three remaining species Ruthven (1912) considers *C. marginata* as synonymous with *C. cinerea*. He adopted the latter specific name on the basis of priority, and thus describes but two species, *C. cinerea* and *C. bellii*. These two species were separated by certain carapace and plastron markings. Applying Ruthven's descriptions to the forms occurring at Madison, the separation of the two species was impossible. Carapace markings were examined and found to be variable and uncertain, in fact, carapace markings typical of *C. bellii* occurred in animals having a typical *C. cinerea* plastron, and *vice versa*. The conclusion that these carapace markings are no longer of any systematic value was confirmed by communications from Ruthven. Differentiation, therefore, must be based wholly upon plastron marking. Figs. 15 and 16 are copies of the plastron drawings of these two species as shown by Ruthven. The former represents *C. bellii* and the latter, *C. cinerea*. While there are individuals occurring here that have typical *bellii* plastrons, and others which have typical *cinerea* plastrons, individuals have been found with plastron markings intermediate between these two "species." More than seven hundred turtles were examined, and practically every degree of variation of plastron marking was found, ranging from the typical *C. oregoniensis*, a common species upon the West Coast, to a form with considerably less color pattern than that shown by Ruthven for *C. cinerea*. Life size drawings were made (see figs. 17-24) of eight selected specimens showing some of these variations. If plastron markings alone are to be the determining factor, where

should the line be drawn to separate these forms into two species? Furthermore, females having one type of plastron may produce offspring of entirely different markings. Unfortunately, the plastron markings of turtle No. 25, from which embryos No. 115 and No. 116 were secured, is not known; however, these embryos, the plastrons of which, drawn to scale, are shown in figures 25 and 26, were taken from the same clutch. The former shows a typical *C. bellii* plastron while the latter shows the plastron typical of *C. cinerea*. There were two other embryos in this clutch which are not figured; one has a plastron marking smaller than that shown in figure 22, while the other is intermediate between figures 21 and 22. There is, evidently, only one species occurring near Madison, or else there is a hopeless hybridization. If the latter be true, it is unaccompanied by any partial sterility such as is usually the case. The relation of these color patterns to geographical distribution in Wisconsin has not been worked out. In Michigan (Ruthven) *C. bellii* occurs in the upper peninsula while *C. cinerea* occurs in the other parts of the state. It would be interesting to find the results in other regions where both forms occur. It seems probable that in regard to these animals the case is similar to that of the song sparrow. In the central region of the distribution we have a mixture of all forms which, west of the Mississippi River, grades through *bellii* into *oregoniensis*, and eastward, into *cinerea* and possibly into *picta*. On this basis the classification would be *Chrysemys cinerea* and *Chrysemys cinerea* var. *belli*. If this classification is adopted or even the rule of priority is applied, then the work of Allen (1904-1906) and that of Van Alten (1914-16) should be designated as being upon *Chrysemys cinerea* rather than *Chrysemys marginata*. In this paper the forms are designated as *Chrysemys cinerea* and no effort is made to differentiate the varieties.

During the collection of the material opportunities were afforded to observe the egg-laying habits of this turtle. In 1919 this species was found to be laying between June 8 and June 26. One female was taken upon high ground June 28, but no nest was found to prove that she had just laid. Dissection showed no eggs in the oviduct.

Collections during the summer of 1920 gave slightly different results. The first turtle taken in oviposition was collected June 8. However, the laying time was considerably extended. No turtles

were found in oviposition later than June 25th, but as late as July 7th turtles bearing fully formed eggs were found crushed upon the road as they were seeking high ground for laying. This latest observation was made by Dr. E. M. Gilbert, but similar previous cases were observed by the writer as late as July 1. The latest date previously reported for these turtles with eggs is July 1, when Ruthven (1910) collected a turtle with ten eggs in the oviduct.

The eggs are usually deposited during the afternoon or evening. One turtle was found packing the hole of the nest at 4:00 p. m., which indicates that the work of nest building was begun before noon. None were found in oviposition in the morning but a number were taken at 4:30 p. m., and a few were just beginning the work of nest building as late as 6:00 p. m.

These turtles select high ground in which to build their nests. Sometimes this is a considerable distance from the water or, where the banks are high, it may be only the distance of a few feet. Usually the ground chosen is hard and dry but a sandy beach may be used. The dirt is first moistened with water from the supernumerary bladder. *This is shown by the fact that the dirt in the hole and surrounding it closely is moist while that farther away is hard and dry. The moistened dirt is worked up and thrown out by the hind feet. It was impossible to determine whether or not the tail was used in digging the hole, as some investigators have reported, since it was always either in the hole or turned up under the plastron while the work was being done. When the hole has reached a depth of from three to four inches a small cave-like excavation is made at one side into which the eggs are dropped without any reference to position. They frequently are found standing on end but more often they are lying on one side. After the last egg has been deposited the dirt is pushed loosely around them and the neck of the nest is packed with wet dirt which is tamped down with the plastron. The nest is then scratched over and is made to resemble the surrounding

* It was considered desirable to determine whether the great quantity of water found in the supernumerary bladder was water removed from the circulation stream or drawn in through the cloaca, since the quantity of liquid in the supernumerary bladder increases markedly during the laying season and decreases after the laying season is past. While the evidence on this point is incomplete, it is thought best to present it at this time. The urine from five turtles was centrifuged and microscopically examined, and since neither diatoms, green algae or protozoa were found, it is doubtful if this is other than excreted water. Chemical examinations were made to determine the percentage of nitrogen compounds in the urine. It was found, in the summer, to be .00055%. Materials for fall determination were lost in transit.

ground so closely that it is difficult to find, especially after the place has become dry.

In the beginning it was deemed best to allow the eggs to incubate under normal conditions. A plan of marking the nests with stakes was adopted. Soon it was found that these nests and many others were opened by some animal, or animals, and the contents of the eggs consumed. Nests were frequently found where the empty shells had been replaced and covered over with loose dirt and sticks. Because of this, the plan of marking the nests was abandoned and all the eggs were brought into the laboratory for artificial incubation.

In the chick the eggs are so produced that they mature at consecutive intervals of time, approximately from twenty-four to forty-eight hours apart, and are laid individually from day to day over a considerable period. An examination of the ovary of the chick shows a graded series of the eggs from the smallest ovarian egg up through sizes to those with fully developed yolks just ready to be shed from the ovary. In *Chelydra serpentina* this is not the case. Here, where a large number of eggs are to be fertilized and laid a brief period of time, are found two types of eggs: the small ovarian egg and the mature egg which is ready to receive the white. The mature eggs of *C. serpentina* are evidently developed simultaneously from the ovarian egg in the season. In *Chrysemys cinerea*, however, a much greater period of time is required to build up the mature egg, possibly four years, since, according to size, the eggs usually occur in four groups. The largest group is composed of eggs the yolks of which are nearly as large as those in fully developed eggs. The second group contains eggs about half as large as the first and the other groups of eggs decrease in size correspondingly. Agassiz noted this fact in *C. picta* and he assumed that it takes four years for the egg to reach the stage where it is ready to receive the white. He stated also that the number of eggs of a given size must represent the number of eggs in a clutch laid by the species. This latter statement seemed a valid assumption but present evidence from *Chrysemys cinerea* shows it to be doubtful. Although specimens were dissected which contained but one egg of a given size, many had groups of two or three eggs. Since never fewer than four eggs were found in the nest or the oviduct of the turtles examined, it would appear that the small eggs may mature rapidly.

The eggs deposited by different individuals vary in number from four to fourteen, with an average of seven. Inasmuch as the size of a turtle is an indicator of its age, comparisons were made to determine whether there is any relation between the age of the turtle and the number of eggs laid. No definite relation is apparent if isolated cases be studied but when the average production of the various sizes is taken a gradual increase in egg number occurs with increasing size, as is shown in the following table:

Length mm.	No. of Individuals.	Av. of Eggs.
130	1	5
135	1	6
140	13	6.38
145	10	7.7
150	5	9
155	10	9.4
160	10	9.9
165	4	10.5
170	2	13.5

The size at which turtles begin to lay is not at all uniform. In *C. picta*, Agassiz states that copulation begins about the seventh year and egg-laying about the eleventh, or at the time that the turtle has reached 80 mm. in length. He estimates that other species begin to lay when from eleven to fourteen years of age. Newman (1906) says of *Graptemys*, that he has never found one nesting when less than 190 mm. in length, or when about fourteen years of age. In *C. cinerea* nesting may begin when the carapace length is only 130 mm.; but oviposition may be delayed until after the length is 150 mm. In the case of one specimen, 187 mm. long, an examination of the ovary revealed the presence of only very small eggs, indicating that the turtle would not lay within a couple of years. This case may have been abnormal.

In some species it is possible to determine the age of turtles by the growth rings on the dorsal plates, much as the age of the fish is determined by the growth rings upon the scales. This method is not applicable to *C. cinerea* since in this species no growth rings are evident. Agassiz noted these rings on some species which he does not name and used a novel method of calculation. Forms in which the rings occurred were measured and from the number of growth rings he determined the age. This standard of measure-

ment was then applied to species in which growth rings were not evident and the age was determined by measuring the length. It seems possible that this calculation proved satisfactory for *C. picta*, since Agassiz held this species under observation for ten years. By this method he determined that egg-laying begins about the eleventh year in *C. picta*, or when the turtle has reached a length of 80 mm. On the basis suggested by Agassiz, a specimen of *C. cinerea*, 130 mm. in length, would be considerably over twenty-five years of age. The great majority, which begin laying when the carapace length is 150 mm., would be very old. In fact, Agassiz cites one case of *C. bellii* as being "very old" with a carapace length of 155 mm.

Through the kindness of Dr. A. S. Pearse, we have been able to secure some data as to the growth in *C. cinerea*. For the past few years turtles have been caught, measured, tagged, and then returned to Lake Mendota. Two such turtles which were caught and tagged August 6, 1917, were again taken on September 12, 1919. Two others that had been tagged September 24, 1919, were taken again; one on May 8, 1920, and the other on June 6, 1920. The data concerning these four turtles is given in the accompanying table:

Date tagged.	Date retaken.	Interim.	Size a	Size b	Increase.
Aug. 6, 1917	Sept. 12, 1919.	2,1, 6.	130 mm.	138 mm.	8 mm
Aug. 6, 1917	Sept. 12, 1919.	2,1, 6.	130 mm.	137 mm.	7 mm
Sept. 24, 1919	May 8, 1920.	0,8,14.	91 mm.	92 mm.	1 mm
Sept. 24, 1919	June 6, 1920.	0,9,12.	66 mm.	70 mm.	4 mm

While these data are insufficient, it has been used as a basis and it has been calculated that a turtle measuring 130 mm. in length would be from eleven to fifteen years of age. If this be true, even approximately, then there is a difference in the growth rate of *C. picta* and *C. cinerea*.

The relation of the length of the turtle to the beginning of egg-laying, based upon the data of 1919 is shown in the accompanying table:

Length.	115 mm.	130 mm.	135 mm.	138 mm.	140 mm.	145 mm.	150 mm.	187 mm.
Total No. of specimens.....	4	4	4	5	6	8	4*	1*
No. with small eggs present.....	4	2	..	..	1	..	..	..
Large eggs present but would not lay in 1920.....	..	..	..	4	..	..	2	1
No. that would lay in 1920.....	..	1	1	..	..	..	2	..
No. having eggs in oviduct.....	..	..	3	1	4	3	..	..
No. taken on nest.....	..	1	..	..	1	5	..	..

* Specimens of this size with no eggs found in oviduct.

From present evidence it appears that there is also a considerable difference in growth rate between the males and the females of *C. cinerea*. The average size of the males taken during the two summers was 117 mm., while the average for the females, for the same time, was 143 mm. The largest female caught measured 187 mm., while the largest male was 175 mm. Another fact which seems to support the idea is that the males become sexually mature by the time they have reached a length of 88 mm., while no females have been found which were sexually mature under 130 mm. A male turtle was considered as being sexually mature when active spermatozoa were found in the *vas deferens*. Sexual maturity in the female is indicated when the first set of eggs begins to enlarge. In the face of these facts, one must assume that there is either a differential growth rate or that the male matures several years earlier than the female. It is to be expected that light will be thrown upon this subject when the hundreds of turtles which have been measured, tagged, and returned to the lake are retaken from year to year.

It has not yet been determined when nor how the eggs are fertilized. It seems a very difficult matter to collect *C. cinerea in copulo*. *Chelydra serpentina* has been observed copulating in the laboratory but this has not been observed for *C. cinerea*. A number of catches were made in the lake when a male and a female were taken together, plastron to plastron, the female being above, usually with the head above water. These were supposed to be copulating. In all such cases the males were much smaller than the females. Two copulating seasons were observed during the year; one in the fall and another in the spring. The opening of the spring copulating season is indicated by the arrival well out in the bay of rather timid individuals. Some of these have been caught with great difficulty and were found to be males. As the season progresses, the females appear in the swampy parts of the lake and are there sought out by the males. Both males and females now become less timid and are easily taken. Soon after the spring copulation laying begins. During September and early October there is a similar congregation of individuals, and spermatozoa can again be found in the oviducts which had been free from them during the latter part of the summer. It was this semi-annual copulation together with the appearance of the eggs in groups that led Agassiz to formulate his theory of progressive ferti-

lization. This theory is contrary to the modern concept of fertilization, and seems untenable, at least in the case of *C. cinerea*, although there is no specific evidence bearing on the case.

There is, however, some contributory evidence. If turtles be taken from their native haunts before the spring copulation season, they produce wholly infertile eggs, and it is only after spermatozoa begin to appear in the oviducts of turtles in their native habitat that fertile eggs are found. It would seem reasonable that the fall copulation should be the fourth for some considerable number of individuals, and hence should initiate cleavage. But no such cleavage is found.

The foregoing observations lead also to the conclusion that the fall copulation is ineffectual for fertilization. The idea that the spermatozoa are retained in the body of the female during the winter and are capable of fertilizing the mature eggs in the spring is also erroneous. In a few weeks after the close of the fall season a careful examination of the uterus, oviducts, bladder and body fluids of a number of specimens failed to reveal any spermatozoa. This leaves still unexplained the presence of a "food mass" observed on the spermatozoa by Glascock (not yet published) which might have been interpreted as an adaptation for this purpose.

As had been suggested, the males and the females are of considerably different sizes when copulation begins. Whether this is due to a differential growth rate or a different age for reaching sexual maturity is undetermined, but the evidence presented here appears to sustain the former idea. That copulation does not begin until sexual maturity has been reached by the females, at least, is evidenced by the fact that the spermatozoa were not observed in the oviducts of sexually immature individuals. One turtle 125 mm. taken after the copulation season was well under way showed no traces of spermatozoa while another, 130 mm. in length, taken five days later, produced fertile eggs. Since, as already shown, the males may have active spermatozoa in the epididymus when they reach a length of 88 mm., it is safe to assume that copulation begins in the male when a carapace length of 85 mm. has been reached. In the case of females, no spermatozoa were found in the turtles with a carapace length of less than 130 mm., therefore copulation must begin about that time.

Development to a certain stage takes place in the oviduct. The great majority of eggs removed from the oviduct had attained the

blastopore stage and remained in that stage. Evidently some condition arrests the development of most of the eggs about the time the blastopore is formed. Several attempts were made to determine the factors which inhibited development. It was thought at first that possibly the egg absorbed water from the soil, since soon after deposition the egg became turgid. To test this idea, uterine eggs were weighed immediately upon their removal from the oviducts, then placed under incubation conditions and weighed from time to time. There was a slight decrease in weight indicating that water was not absorbed from the outside during the development of the egg. Eggs were also incubated under moist conditions without contact of soil and were found to develop normally, indicating that soil has nothing to do with the initiation of development. This left only the assumption that either the gases of the air or those dissolved in water were responsible for the renewal of embryological processes. Whole oviducts containing the eggs were removed, tied at each end and placed under incubation conditions, but without results. The failure of these eggs to develop, however, might reasonably be traced to the decay of the tissue of the oviduct. Further experimentation will be carried out along this line. It is quite possible that the physical change in the shell from the hard, inflexible shell in the oviduct to the soft, flexible shell in the nest permits a freer flow of gases. At any rate, this renewal of development is co-incident with a change in the albumen from a thick to a thin substance, with a corresponding increase in pressure.

While as a rule the eggs taken from the oviduct are in the blastopore stage, some of them are found in the cleavage stages and others in the earliest flexure stages. Embryo No. 38, fig. 33, was found to be in this flexure condition. This was the second egg to enter the oviduct and it was opened immediately upon its removal. This embryo shows a greater development than those behind it in the oviduct.

Agassiz noted that a turtle might lay eggs that had been retained for a considerable time. He found, however, that in most cases such eggs developed into monstrosities.

This is not necessarily true as is shown in the following experiment. A turtle was caught, June 12, in the act of digging a nest. She was placed in a tank of water, without sand, and kept until July 10, when she was dissected. Of the seven eggs covered by shells,

four were opened and found to be in blastopore stages. One of these is shown in fig. 27. It is to be noted that this egg, although retained for a month, had not passed beyond the blastopore stage, and it seems reasonable to suppose that the development of the three unopened eggs was about the same. The three unopened eggs were placed under incubation conditions. Figure 10 was made from one of the eggs from this clutch, artificially incubated for forty-eight days. Figure 11 is a drawing of a specimen from a non-retained egg which was incubated for forty-three days. A comparison of these two embryos shows that no unsatisfactory results came from such retention. In order to determine how long they could be forced to retain their eggs, turtles collected early in June were kept in tanks of water without sand until the latter part of July, when some of them, at least, laid their eggs in the water and presumably ate them, for the only evidence of such deposition was the empty egg shells. Dissections of a number of individuals at a later time showed no traces of eggs.

ARTIFICIAL INCUBATION

Up to date, efforts to incubate artificially the eggs of turtles and terrapins have not been very satisfactory, although several successful attempts have been reported. One of these cases is related by Pease (1910), who carried home some newly laid eggs to show the children. These eggs were carelessly left in a tin box on the pantry shelf and in due time they hatched. Neither the species nor any other detail was given. Another plan, used commercially, is reported by Moulton (1914) who states that the eggs of the diamond-back terrapin are collected from the sandpiles in which they are laid, placed in boxes of sand, and sprinkled with water weekly until they hatch. Little data is given. Hochstetter (1906) mentions the artificial incubation of some fifty eggs for embryological purposes, by a method similar to that reported by Moulton.

Before any of the papers mentioned above had come to the knowledge of the writer, the following experiments had been successfully carried out. The first effort of the writer to incubate Chelonian eggs, artificially, was made in the summer of 1918 at Trinity College, Durham, North Carolina. Four eggs, secured from a potato hill near Farmville, Virginia, about the middle of August, were

placed in a box of sand, without any reference to their previous position, and carried about one hundred miles to the laboratory, where they were placed in a bucket of moist dirt which was covered with a bell jar. About the middle of September four little terrapins of an undetermined species made their appearance. It is surprising, when the careless handling of these eggs is considered, that they hatched, for if such treatment had been given the eggs of *Chrysemys cinerea*, the embryos would have died. This indicates a fundamental difference in the egg structure of these two forms; the blastodisc of this terrapin egg, like that of the hen's egg, did not stick to the shell membrane but rotated as the egg was placed in various positions. In the summer of 1919 the eggs of the painted turtle were brought into the laboratory of the University of Wisconsin and placed in buckets of dirt, covered with bell jars. From such eggs embryos were secured. In these experiments newly laid eggs (not over a few hours old) and uterine eggs were used. The former were frequently collected before the the completion of the packing of the hole of the nest but never before the laying was finished. Uterine eggs were removed directly from the female. A summary of the results of the incubation of the uterine and the laid eggs for the first summer is here given:

	Total No. Clutches	Total No. Eggs	Total No. Embryos	Per Cent Development
Laid	6	32	11	34.4
Uterine	19	135	99	73.3

During the second and third summers practically none but uterine eggs were used, but owing to the fact that many turtles were taken before the copulating season began, the data on fertility would be unreliable, and is therefore not included.

Uterine eggs of other species have been examined by other students, but no reports have been found which would indicate that the incubation of uterine eggs had ever been attempted. The value of such incubation will be pointed out later in the paper.

Although it is necessary to kill the turtle to secure the uterine eggs, this has its recompense, since from four to ten eggs are secured from each turtle. These represent various stages of development between early cleavage and the first flexure stages. Such a variety of phases in a single individual does not seem to be available in any other animal. If the turtle is taken early in the breeding sea-

son cleavage stages are very likely to be found, although the majority of eggs will be in the blastopore stage. This condition makes the turtle an excellent animal from which to secure the blastopore stages of the discoidal cleavage type for class work, since a single turtle may produce six or more eggs in this stage, whereas the hen, which must also be killed in order to secure the blastopore stage, will produce but a single egg in this condition.* The use of turtle eggs permits of a comparative study of the development of eggs of a clutch which have, in the very nature of things, much more in common than any group of hen eggs. Furthermore, turtle eggs may be placed under identical incubation conditions immediately upon removal from the oviduct, while the hen eggs, which are laid from day to day, are subject to varying external conditions before incubation.

For incubation, the eggs of *Chrysemys cinerea* are buried to a depth of about one inch in horizontal position in a battery jar of moist sand. Each group is labeled with a peg bearing the number of the turtle. The embryos are numbered as they are removed from the eggs and fixed.

A few precautions are necessary in the artificial incubation of *C. cinerea* eggs. In the first place, if eggs which have been laid are to be incubated, they must be secured early after deposition, since in from twenty-four to thirty-six hours after laying the embryonic disc comes to lie just above the yolk level, either at the top or the side or at the end of the egg, and attaches itself to the shell membrane. Any change in the position of the egg, even as little as a quarter of a turn, after this, may cause the yolk to settle over the embryo and the development will cease, or become abnormal. This probably accounts for the failure of many attempts at artificial incubation where the eggs are brought in from the field several hours after deposition.

A proper moisture content also is essential for success. Eggs of the painted turtle exposed to the air of laboratories soon become wrinkled and finally collapse. In the case of the snapping turtle, the shell is much tougher and the shriveling does not take place but the moisture leaves the egg and the yolk becomes a hardened mass within the shell. Seven "snapper" eggs were completely dried at

* Recent work by Riddle (1921) would indicate that blastopore stages may be secured from live hens by intramuscular injections.

the close of twenty-eight days. Eggs from the same clutch, kept under moist conditions, continued to develop.

Temperature, of course, plays its part, although a room with a southern exposure gives sufficient heat for reasonably rapid development. In this connection it was thought desirable to determine the effect of cold upon the rate of development. For this experiment the eggs from turtles No. 128 and No. 129 were placed under the usual incubation conditions except that they were put in a refrigerator. After a period of about one month one of these was opened and found to be in the blastopore stage, indicating that development does not proceed at temperatures near the freezing point. The eggs, however, were not injured by the cold, for when placed under the natural heat conditions of the room they began to develop in the normal manner. In order to determine the relative rate of development, indoors and out, three eggs from each of the specimens No. 36, No. 37, and No. 38 were buried in an artificial nest out of doors, exposed to all natural conditions. The remaining eggs from each of these specimens were placed under incubation in the laboratory. From time to time these eggs were opened. Embryo No. 88, fig. 11, was incubated in the laboratory forty-three days, while embryo No. 100, fig. 12, was incubated out of doors in an artificial nest for forty-seven days. Development proved to be about as rapid in the laboratory as outside.

The presence of soil around the egg is not necessary. This has been tried out in one case with the eggs of the "snapper." Five eggs from a clutch of eleven were placed in a finger bowl without sand or water, (see a, in table below). The remaining six were placed in moist sand, (see b, table below). The two bowls were placed in a glass dish which contained a small quantity of water and covered with a bell jar. Incubation was allowed to go on for a few days and then the eggs were opened with the following results:

(a) 5 eggs—3 embryos, 1 dead, 1 egg infertile.
(b) 6 eggs—3 embryos, 1 dead, 2 eggs infertile.

Although the eggs develop without soil, nevertheless, it serves the useful purpose of holding the eggs in position during development.

The rate of development of the uterine egg is about the same as that of the laid egg. An examination of the drawings of embryo No. 68, fig. 34, which was incubated twenty days, and of embryo No.

69, fig. 37, incubated seventeen days, shows that the latter, which is from a laid egg, is slightly more in advance, as would be expected. Comparison of embryo No. 92, fig. 10, and No. 99, fig. 13, shows that the former, which is from a uterine egg, is more advanced. In this case, also, the laid egg was incubated three days longer than the uterine egg.

Even among uterine eggs there is a variation in the rate of development. Two eggs were placed under identical incubation conditions, one day apart, and were opened on the same day. From these embryos No. 80, fig. 39, and No. 81, fig. 38, were obtained. Embryo No. 80 is considerably more developed than No. 81 would be if it had been incubated for the same time. Such difference may possibly be due, in some degree, to the extent of the egg development in the uterus, but more likely it is due to the different developmental rates.

Altogether one hundred and sixty-seven eggs were incubated the first year. From these one hundred and ten embryos, or slightly over sixty-six per cent, developed. During the second summer, three hundred and five eggs were handled from thirty-five clutches. Since a number of these clutches were taken from turtles collected before the spring copulation season began, there is a rather high percentage of infertility, some ten clutches failing to have any eggs develop.

The ease with which turtles may be secured and incubation carried on, and the high percentage of fertility, make the turtle an excellent subject for embryological work.

PREPARATION OF MATERIAL

Some of the eggs collected were opened immediately and some were artificially incubated according to the method just described. The embryos were all killed in Bouin's fluid, stained in Alum Cochineal *in toto* and sectioned in paraffine. In this manner some two hundred and forty embryos have been prepared for study.

DEVELOPMENT HISTORY THROUGH GASTRULATION

As stated earlier in this paper, many of the eggs studied were removed from the oviduct and artificially incubated. No fertilization stages were found.

CLEAVAGE

Since *Chrysemys cinerea* deposits its eggs in an advanced stage, considerable difficulty was experienced in finding cleavage stages. Two eggs were taken having sixty-four or more cells arranged in a discoidal plate. In appearance they were similar to those of the pigeon eggs photographed by Miss Blount and published in Lillie's (1908) text, page 45, fig. C. On account of the hardness of the embryos, sections were not secured.

FORMATION OF BLASTULA

The formation of the blastula in Chelonians has been studied by Agassiz (1. c.), Will (1893) and Mitsukuri (1896). The sections show a layer of rather large cells, co-extensive with the blastodisc, and underlying these, a layer of more spherical cells. The former is at once recognized as the ectoderm and the latter as the yolk endoderm. There is sometimes a cavity present which may be called a segmentation cavity. In the earlier works it was called a Baerische Höhle, and was figured by Will (1. c.).

SOME OBSERVATIONS UPON GASTRULATION AND THE FORMATION OF THE BLASTOPORE

Keibel (1905) raised the question as to the advisability of dividing the process of gastrulation into two parts. He suggested that the part involving invagination or involution be considered as the first part and the formation of the mesoderm as the second. This plan has been adopted in this paper.

Mehnert's work (1892) concerning the process of gastrulation is by far the most complete, and carries an excellent bibliography. Mitsukuri (1893) published a preliminary note upon this process, which was more fully treated by him in 1894. There is nothing unusual in the process. The views of these writers will be given later.

The earliest stage of gastrulation is shown by the first invagination of the ectoderm to form a small cup. This is commonly known as the blastopore stage. No trouble was experienced in securing it, since by far the greater number of eggs opened immediately were found to be in this condition. Altogether, twenty such embryos have

been mounted whole or sectioned. In *Chrysemys cinerea*, the blastopore is well within the germinal disc and is usually located asymmetrically in reference to length, about one-third of the total length distant from the posterior end. Figure 30 shows a typical case. In some species the blastopore seems to be in such a position as to extend beyond the end of the disc, as figured by Mitsukuri (1894). Several stages of the closing of the blastopore are shown in the mounted specimens. The opening, which was originally round, comes to form first an oval and then an almost straight slit which later becomes slightly curved with the points of the crescent towards the anterior part of the body.

The cavity formed by the invagination at first pushes directly downward and then suddenly bends cephalad, forming two layers of ectodermal cells, the small space between which is probably the segmentation cavity. The space continuous with the blastoporic canal is the archenteron, the roof of which is formed by the invaginated cells and the floor by the cells of the yolk endoderm. Mitsukuri (1894) was the first to identify this cavity in *Trionyx* as the archenteron. Older specimens were found in which the endoderm had disappeared from the floor and the invagination cavity was continuous with the space at the top of the yolk. Will (1893) and Mitsukuri have had considerable argument as to the extent of this archenteronic cavity before its entrance into the yolk cavity. The former held that it was co-extensive with the disc while the latter maintained that it was in no way approximately equal in size to the disc. Observations upon *Chrysemys cinerea* confirm the idea of Mitsukuri. However, Will may also be correct for the form which he discussed, since generic differences have been shown to exist.

The primitive knot is on the posterior side of the blastopore. When it is not covered with ectoderm it is considered a yolk plug. Such an uncovered knob was found by Mitsukuri and Ishikawa in 1886 in *Trionyx japonicus*, which is one of the snapping turtles. They at once formulated the idea of homology of the yolk plug in reptiles and amphibians. Robinson and Assheaton (1891) disagree with the homology suggested by Mitsukuri and Ishikawa. Kupffer (1882) did not find the yolk plug in reptilia. *Chelydra serpentina* is also a species of the "snapper," and shows this yolk plug as is seen in figures 31, 32, 35, and 36. These drawings were made from mounts already in the University of Wisconsin embryological collections.

They show essentially the same features as are figured by Mitsukuri and Ishikawa.

Similar conditions are not found in *Chrysemys cinerea*, since the yolk is plainly covered with ectoderm for some distance down into the blastoporal canal (see fig. 29). This is brought about in the following manner: At the posterior end of the primitive plate, before the beginning of invagination, there is proliferated a group of cells of endodermal origin. These are covered over with a layer of ectoderm. When invagination begins, the ectoderm forms a cup which seems to sink into these lower cells. Ultimately the ectodermal cells break and the part forming the anterior wall of the blastoporal cavity turns cephalad, forming a layer of cells under the ectoderm. In *Chrysemys cinerea* this rupture of the ectoderm takes place at the bottom of the cup when it has reached its greatest depth before turning cephalad. This leaves a part of the endodermal cells of the primitive knob covered with ectoderm, as indicated above. On the other hand, Mitsukuri (1896) found in the forms which he studied, (*Trionyx Japonicus* and others), that the primitive knob was never completely covered with ectoderm but that when the ectoderm had spread over about one-half the outer surface it began to invaginate, leaving the latter half of the primitive knob uncovered. To this uncovered part he applied the term yolk plug. Earlier in this paper such a condition has been shown to exist in *Chelydra serpentina*. This was the basis upon which Mitsukuri constructed his theory as to the homology of this structure in *Elasmobranchii*, *Chelonia*, *Amphibia* and *Mammalia*. He states that no such structure (i. e., yolk plug) has been reported for birds, "probably due to the fact that nobody has looked for it." He finds a closer analogy between *Elasmobranchii* and *Chelonia* than between *Amphibia* and *Chelonia*. In the examination of several species he found that the more specialized the Chelonian studied, the less distinct was the yolk plug. If this be true, the non-occurrence of yolk plugs in *Chrysemys cinerea* means that this species is farther removed from the ancestral type than *Trionyx japonicus* and *Chelydra serpentina*. Other facts concerning these two forms lead to the same conclusion.

Soon after invagination begins there is a thickening of the ectoderm in the median longitudinal line. This represents the primitive plate. Previous to this thickening the head fold becomes visible at the anterior end of the disc, but it is not nearly so marked as is

figured by Agassiz (l. c.). In fact, Agassiz (see Agassiz, plate 9-e) makes the head fold the first to develop. Certainly, such is not the case in *Chrysemys cinerea*.

SUMMARY

1. *Chrysemys cinerea* is shown to be the only species occurring in the vicinity of Madison, Wisconsin.

(a) There are no constant differences of markings in the forms occurring there by which *C. cinerea* and *C. bellii* can be separated.

(b) *Chrysemys marginata* and *Chrysemys cinerea* have been previously combined as a single species, the latter name being adopted on the basis of priority. The impossibility of differentiation between *C. cinerea* and *C. bellii* requires that but one species be recognized. Priority designates it as *C. cinerea*.

(c) While hybridization is possible, the undiminished fecundity of these forms indicates that they are not hybrids.

(d) It is more probable that geographical varieties occur in different regions, as is the case with the song sparrow.

2. The egg-laying period was found to extend from June 8 to June 26, with a possible extension of time to July 7. Turtles were observed in oviposition from 3:30 p. m. to 6:00 p. m., but indications were that egg-laying may be carried on any time from 12:00 m. to 10:00 p. m.

3. It was found that the supernumerary bladder is used for moistening the soil in digging the nest. That the water contained therein was excretory in nature.

4. The number of eggs in a clutch varies from four to fourteen. The number of eggs in the "groups" in the ovary varies from one upwards to fifteen.

5. *Chrysemys cinerea* may begin laying when it reaches a length of one hundred and thirty millimeters and, apparently, there is a relation between the size of the turtle and the number of eggs laid.

6. The nests are opened by some unknown animal which destroys the eggs. This led to the use of artificial incubation.

7. The possibility of artificial incubation has been shown and successful methods have been described.

8. Uterine eggs may be used with even better results than can be obtained with laid eggs.

9. Contrary to general opinion, no great care is necessary in handling turtles or their eggs, provided uterine eggs or newly laid eggs are used. Embryos may be opened in normal saline without distortion.

10. Eggs that have been retained by a turtle for a month will produce apparently normal embryos when incubated.

11. Development in the oviduct ceases about the time the blastopore is formed, but may be arrested in the cleavage stages, or may proceed to the first flexure stage.

12. The rate of development is approximately the same in artificial incubation as it is under normal conditions. There is probably quite a difference in the development rate of various eggs of the same clutch.

13. Cleavage in *Chrysemys cinerea* is similar to that of any discoidal cleavage form.

14. In the blastula the lower part is formed by yolk endoderm while the upper part is formed by ectoderm. There is a cavity between them similar to the cleavage cavity of other forms.

15. In *Chelydra serpentina* a yolk plug occurs but it does not occur in *Chrysemys cinerea*. This, with other considerations, indicates that *C. cinerea* is more specialized than *Chelydra serpentina*.

16. The rounded blastopore in closing forms first an oval and then a crescent.

17. The blastopore is formed by an invagination of the ectoderm.

18. In *Chrysemys cinerea*, as in *Trionyx*, the anterior part of the blastoporeal canal forms the archenteron.

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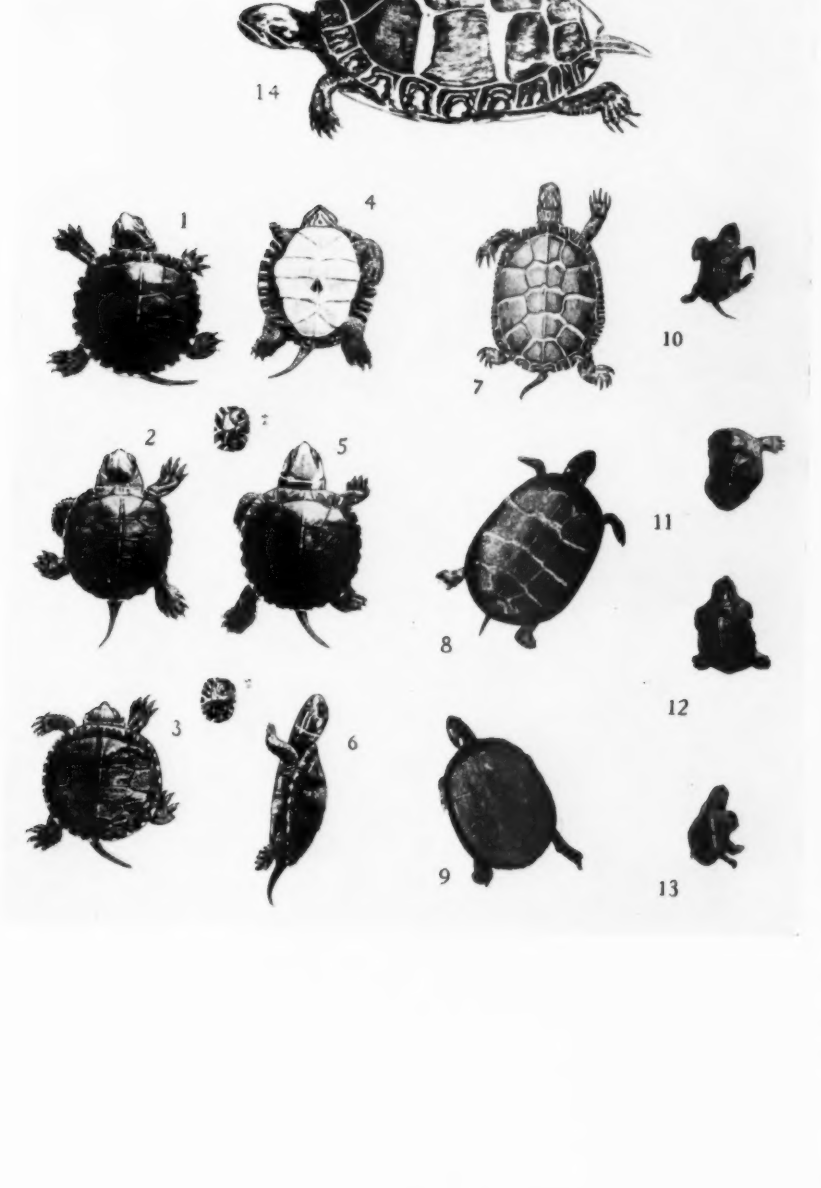
PLATE 2



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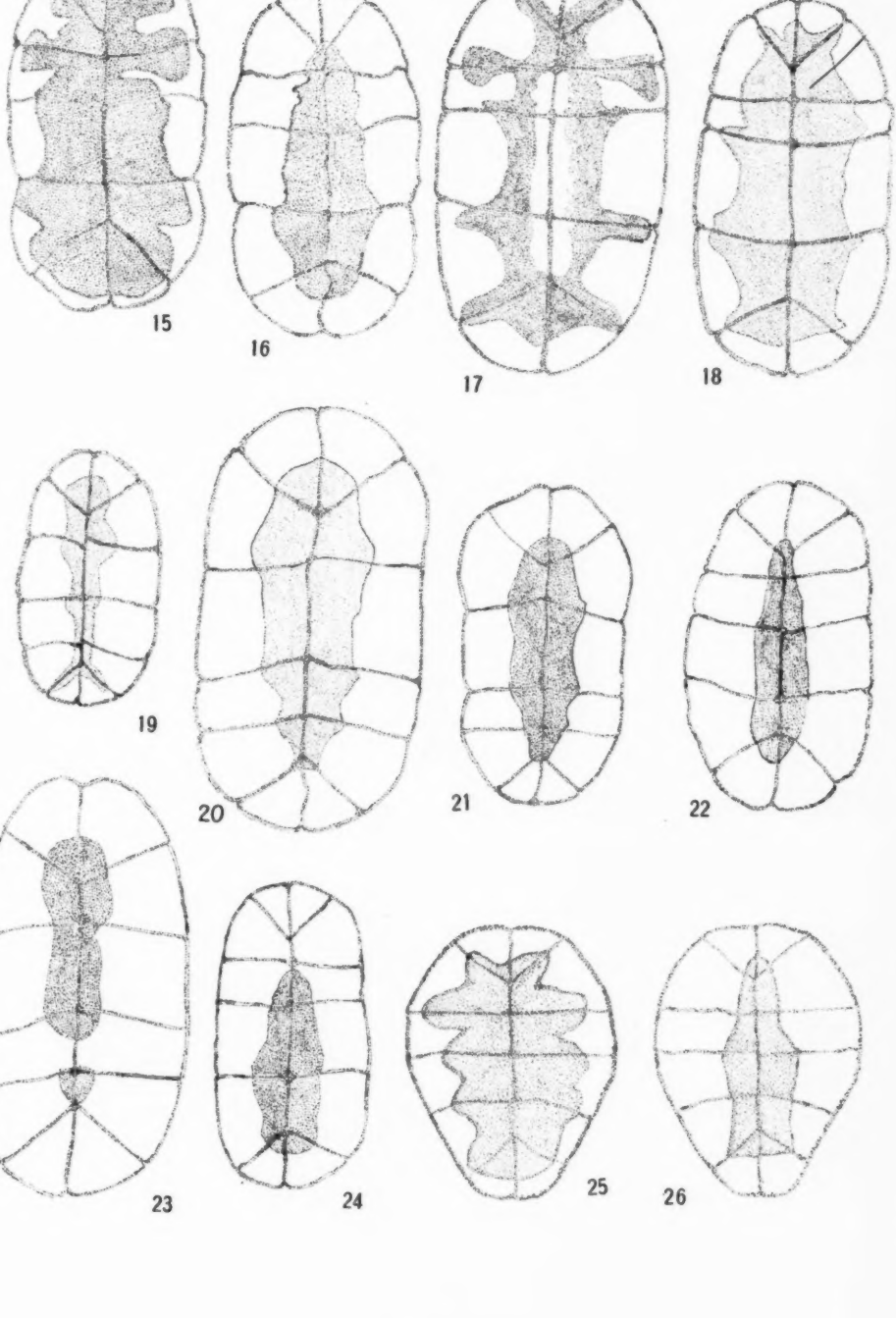

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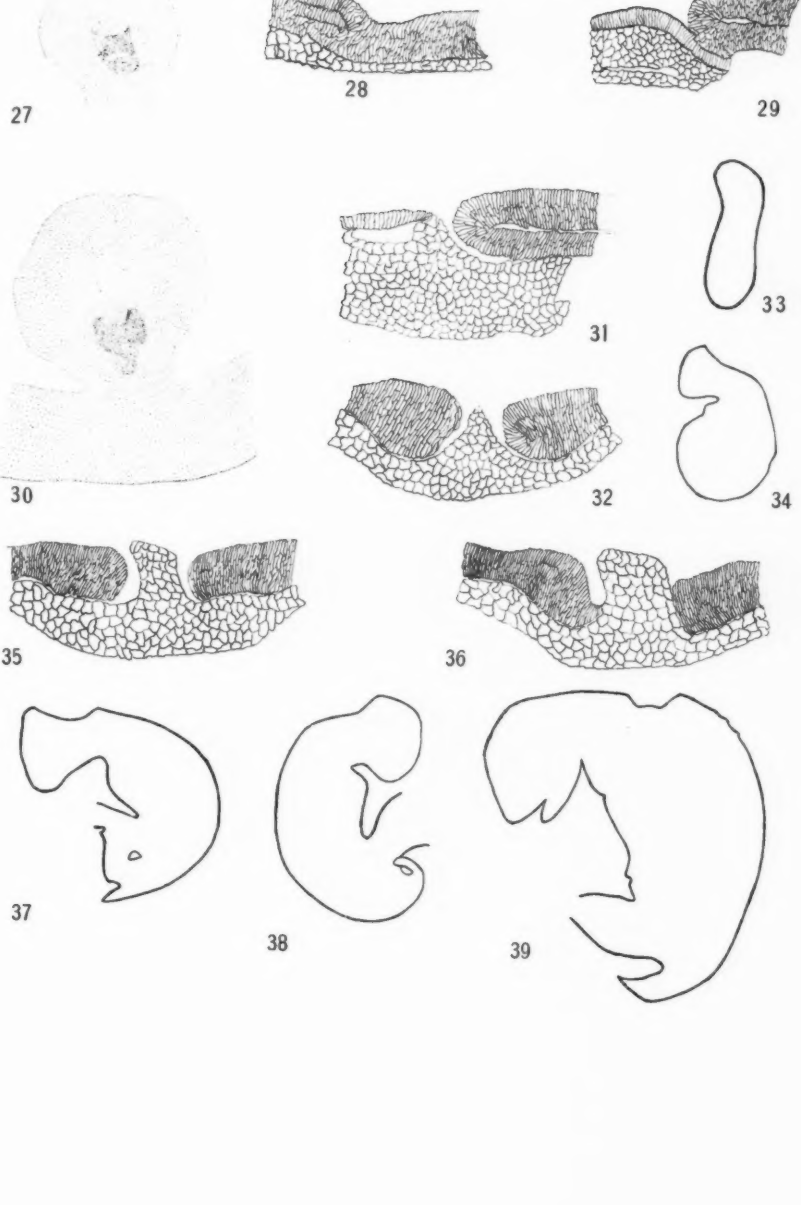

EXPLANATION OF PLATES 2-4

Figs. 1, 3-6, *Chrysemys picta* after Agassiz.
Fig. 2, *Chrysemys marginata* after Agassiz.
Fig. 7, *Chrysemys picta* after Gadow.
Fig. 8, *Chrysemys picta* after Ditmars. Photographs by permission.
Fig. 9, *Chrysemys marginata* after Ditmars. Photographs by permission.
Fig. 10, Photograph of *C. cinerea*. Uterine egg retained for 30 days. Incubated 48 days.
Fig. 11, Photograph of *C. cinerea*. Incubated 43 days out-of-doors.
Fig. 12, Photograph of *C. cinerea*. Incubated 47 days indoors.
Fig. 13, Photograph of *C. cinerea*. Laid egg incubated for 45 days.
Fig. 14, *C. picta* Hermann, after Schoepff.
Fig. 15, Plastron of *C. bellii* after Ruthven.
Fig. 16, Plastron of *C. cinerea* after Ruthven.
Figs. 17-24, Drawings of plastrons of various specimens showing gradations of plastron markings between these figured in 15-16.
Figs. 25-26, Drawings of plastrons of two specimens from the same clutch.
Fig. 27, Blastopore stage of *C. cinerea*. Egg retained 30 days.
Fig. 28, Transverse section showing invagination of *C. cinerea*.
Fig. 29, Sagital section of a later stage showing ectodermal cells posterior to blastopore.
Fig. 30, Blastopore stage typical of *C. cinerea*.
Figs. 31, 32, 35, 36, Yolk plug of *Chelydra serpentina*.
Fig. 33, Early flexure stage. Egg opened upon removal from oviduct.
Fig. 34, Outline drawing of embryo of *C. cinerea*. Uterine egg incubated 20 days.
Fig. 37, Outline drawing of *C. cinerea* embryo. Laid egg incubated 17 days.
Fig. 38, Outline drawing of *C. cinerea* embryo. Uterine egg incubated 28 days.
Fig. 39, Outline drawing of *C. cinerea* embryo. Uterine egg incubated 30 days.
Figs. 10-13, slightly reduced; 15-24 reduced ½; 25-26 x 2½; 27 x 12; 28-29 x 50; 30 x 20; 31, 32 x 50; 33 x 8; 34 x 4; 35, 36 x 50; 37 x 6; 38 x 5; 39 x 3.

REACTION OF METHANE AND ALSO OF ACETYLENE UPON ZIRCONIUM TETRACHLORIDE

By F. P. Venable and R. O. Deitz

The reactions of zirconium tetrachloride with certain hydrides as ammonia, phosphine, and hydrogen sulphide have been investigated in so far as the changes taking place in the zirconium compound are concerned. There are first formed with ammonia addition compounds which on heating yield nitrides and hydrogen chloride. With phosphine zirconium phosphide is formed and with hydrogen sulphide the product is zirconium sulphide.

As zirconium carbide is somewhat imperfectly known, it seemed of interest to examine the reaction between zirconium tetrachloride and certain hydrocarbons. The carbide was prepared by Troost,[1] who heated powdered zircons with carbon in an electric furnace, obtaining a substance which on analysis yielded results agreeing fairly with the formula ZrC_2, but no distinction was made between free and combined carbon. Moissan[2] prepared the carbide by fusing zirconia with carbon, varying the amount of carbon in different fusions and obtaining a substance of consistent composition agreeing with the formula ZrC. Wedekind[3] later confirmed the work of Moissan. So it may be concluded that normally zirconia reacts with carbon at high temperatures, forming a carbide containing one atom of each of the combining elements in the molecule.

For the following experiments zirconium tetrachloride was prepared and freed from traces of iron by the method used by Venable and Bell.[4] It was retained in a hard glass tube where it could be volatilized by means of an electric sleeve. Every precaution was taken to avoid the presence of traces of water which would hydrolyze the tetrachloride.

Methane was prepared by heating anhydrous sodium acetate and soda lime and was dried before admission to the reaction tube. This tube contained about 5 grams of $ZrCl_4$ which was volatilized during the passage of the methane. Apparently no reaction took place

[1] Compt. rend. 116, 1227. 1893.
[2] Compt. rend. **116**. 1222. 1893.
[3] Ann. **395**. 149. 1912.
[4] Amer. Chem. Soc. **39**. 1598. 1917.

below the temperature of vaporization. The tetrachloride began to darken at about 400°. About 13 l. of methane were used in a slow stream. After about one-third of the methane had been used no further volatilization of the tetrachloride was observed. When the reaction tube was opened after cooling there was observed a peculiar odor resembling that given off when sulphuric acid through which methane has been bubbled is diluted with water. This may indicate the formation of condensation hydrocarbons either in the drying train containing P_2O_5 or in the reaction tube in the presence of heated $ZrCl_4$.

The contents of the reaction tube were washed out with water to remove zirconium chlorides and after thorough washing three undissolved products were distinguished under a magnifying glass as follows: (1) Black particles, (2) lighter brownish particles which were easily blown about by slight air currents, and (3) masses which were largely colorless but held small black particles disseminated through them. The total yield was only a small fraction of a gram, showing that in spite of prolonged heating with an excess of methane the reactions taking place were quite limited in extent. From two runs of 5 g. $ZrCl_4$ each, 0.51 g. of the black particles were obtained and the separation could not be looked upon as complete.

Separation of these different particles by flotation in various liquids was attempted but proved unsatisfactory. Various solvents were tried also without success. Concentrated nitric acid reacted upon the mixture, as also did sulphuric acid. After partial separation by flotation followed by picking out the particles as far as possible under a magnifying glass about 0.5 gram of the black particles were secured and analyzed. The percentage of carbon found was 32.09. Later the experiment was repeated with some additional precautions and a sample obtained yielding 28.11 p.c. carbon. From these analyses it was concluded that the black particles contained a considerable admixture of free carbon, since the percentage for ZrC is 11.69 and for ZrC_2 20.95.

The investigation of the reaction with acetylene showed that it began on gentle heating and was exothermic. Gradations in color from brown-red to black were observed in the product and on washing with water a mixture apparently similar to the above was obtained.

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SOME PHASES OF STRUCTURE AND DEVELOPMENT OF GARDEN PEA AND WHITE SWEET CLOVER SEEDS AS RELATED TO HARDNESS

By L. Edwin Yocum

Plates 5 and 6

Hard seed coats are very common among the *Leguminosae*. Guppy (7) mentions 32 legume seeds in a list of 43 plants whose seeds are more or less hard. Harrington (8) has found in hand hulled seeds the following percentages of hard seeds: alsike clover, 92%; red clover, 92%; white clover, 98%; and white sweet clover, 98%. Therefore, it is of vast economic importance to determine some way of inducing all the legume seeds to germinate soon after sowing rather than months or years later, which is often the cause of a poor stand of clover. The purpose of this paper is: (1) to trace the development of the garden pea and white sweet clover seed coats, and (2) to find out the chemical composition of the cell walls. It is hoped that these factors may throw light on the cause of hardness and suggest some method of overcoming the hardness of the seed coats which will be more practical to the farmer than any of the present methods. The Malpighian cells have been found to be most important as regards hardness, and therefore most emphasis will be put on the study of that layer of cells.

Hard seeds are considered as those failing to absorb water when under favorable conditions for three or more days.

Historical

Seed coats have been investigated from time to time since 1667 when Malpighi described the cells now bearing his name. Russow, 1871, studied the light line with polarized light and came to the conclusion that it had less water than other parts of the cell. Pammel, (12) 1885, examined several of the *Leguminosae*, and again, Pammel, (13) 1899, published a monumental work on the anatomical characters of the *Leguminosae*, with excellent figures, and an extensive bibliography.

Workers began to turn their attention to the treatment of hard seeds about 1890. Kuntz and Huss used sand paper as a scratching machine. Other investigators have used various forms of sand paper scratchers. In the past ten years most investigators have used some modification of throwing or blowing seeds against sharp points or needles as a means of puncturing the seed coat. Carruthers, (2) 1911, was able to guarantee 98-100 per cent germination of clover seed with a machine of this type. Rose, (14) in 1915, explains a device where seeds are blown against a pad of needles, which very effectively improves germination. Prof. Hughes of Iowa State College has invented a similar but less complicated machine which is fairly satisfactory and is in use by some seedsmen.

Harrington, (8) 1915, shows the effectiveness of clover hullers as scratching machines. He finds that while hand hulled white sweet clover has 98 per cent of hard seeds, machine hulled has only 20 per cent of hard seeds. Hulling, however, injures some of the seed when set to get the maximum scratching results.

Hot water treatment has been recommended for a number of years. Jarzymowski, in 1905, used it with some success with legume seeds. Bolley, (1) in 1910, reports success with hot water provided the treatment was not so long as to injure the embryo.

Chemical treatments are receiving more and more attention. Rostrup, (15) in 1896, treats *Lathyrus sylvestris* seeds for one minute in sulphuric acid and had 100 per cent germination. Bolley (1) has used sulphuric similar to the way it is used by Love and Leighty, (11) in 1912, who treated seed for 10 to 30 minutes to get maximum results. Periods of more than one hour usually injure the seed.

Many other chemicals have been used; however, the lower alcohols seem to be most effective. Verschoffelts thinks the water will not wet the cell walls, but alcohol can do this more easily. After the walls are wet they can absorb water. Coe and Martin (3) find that the alcohol treatment is not effective with white sweet clover.

Several explanations have been offered for dormancy or poor germination of seeds. Crocker, (4 and 5) in 1916, gives a representative list of probable causes. He attributes dormancy in many cases to the hard seed coat, which keeps out water and possibly oxygen. The impermeable portion may be the cutin or the light line. Coe and Martin (3) show by staining whole seeds that the light line is undoubtedly the limiting factor of absorption, since the stain enters

readily to, but does not stain, nor pass beyond the light line. The light line is very much harder than other portions. They have found that while the outer portion of the seed is readily eaten by sulfuric acid, the light line is not destroyed by it. The paper also contains a very extensive list of the important literature.

Some work has been done on the hereditary possibilities of hardness. Harrington (8) gives an account of the tests on the experimental farms, 1909-14. He says the percentage of hard seeds has been as great from seeds when only 5 per cent were hard as from seeds when 95 per cent had been hard.

Hiltner and Kinzel (10) find that the percentage of hard seeds is higher in some years than others, and that perhaps weather conditions have an effect. They also find that rapid drying, 30° to 40°C. increases hardness. Harrington (8) and Coe and Martin (3) have not found a seasonal relation.

MATERIAL AND METHODS

All stages of development of garden peas and white sweet clover seed coats, except those fully mature, were killed in chromoacetic acid, imbedded, cut and finally stained with either safranin and light green, or haematoxylin and safranin. Mature stages were taken from free hand sections. In some cases the flowers were tripped and age of seed figured from date of tripping, in other cases it is estimated from the time the flower wilts which is considered as the time of fertilization.

All microchemical work was done on fresh material grown in the green house. The methods followed were those outlined by Zimmermann, Hass and Hill, and Tunmann.

In this work hardness in peas was determined by soaking for three days. Less than 1 per cent of most peas are hard. Some few, however, appear to have hard seed coats, but admit water at the hilum, as shown by swelling around that region first, as well as by staining. Sweet clover seeds were placed in germinator for 10 days and those not swelled were considered hard.

DEVELOPMENT OF SEED COAT

These legumes have their seed coats made up almost entirely of the outer integument. The inner integument in sweet clover never

develops more than two or three rows of large cells. The garden pea forms six to eight rows of cells in the inner integument but never forms the cells so compactly as in the outer integument; however, the two gradually shade off together. The inner integument in both cases soon partially breaks down.

The outer integument in sweet clover is made up of from five to eight rows of cells. The garden pea has from six to ten layers of cells in the outer integument. The former number is common at the time of fertilization and the remainder are added soon after.

The sweet clover seed coat has almost cubical Malpighian cells at the time of fertilization, with thin walls slightly thicker at the outside. In six days the Malpighian cells begin to elongate and divide so as to become very narrow. This elongation and division goes on very rapidly for about eight days, when it appears that possibly the total number of cells have been formed and that these get wider to accommodate the later growth of the seed.

The cell walls begin to thicken soon after fertilization, and decided thickening takes place on the outside at the time the cells elongate. The domes begin to thicken in nine days and are completely formed in about twenty days. The light line does not appear until the seed is nearly mature.

A very striking contrast is found between hard and soft seeds. Hard seeds have their walls thickened so much below the light line that the lumen extends only part of the way from the base to the light line. In soft seeds a fairly large lumen extends to the light line. This may allow larger pores to extend through the light line.

The thickening of the cell walls of sweet clover and peas is similar in that both are thickened in ridges leaving crevices between the various thickened portions. The crevices are usually very narrow.

In the garden pea the cell walls are generally thinner, especially in young stages, than in sweet clover. The Malpighian cells change very little for several days after fertilization. The remainder of the cells of the integument enlarge very much. In about six days the Malpighian cells elongate to several times their width and thicken a very small amount. Thickenings come in very rapidly at the time the seeds are nearly mature.

The cells sometimes entirely close up due to thickenings, as in the case of hard seeds. Seeds which are not hard usually have the

lumen extending nearly the length of the cell, although the walls are very much thickened.

CHEMICAL COMPOSITION OF CELLS IN GARDEN PEA

In very young flowers where the anthers were not open, light green stains the walls nearly equal around the ovule. Ruthenin red shows very little staining at any point. Methylene blue stains cell contents, walls lightly if any. Cupro-ammonia destroys the walls entirely in one hour. Chloroiodide of zinc stains brown color. This indicates generally cellulose but not definitely.

At the time of fertilization, all the cells except those of the micropylar region remained the same. At the micropyle the light green does not stain. Ruthenin red stains distinctly at micropyle. Methylene blue stains cell walls deep blue, and destains in alcohol. In cupro-ammonia micropyle cells are more resistant, remain intact after two hours. This indicates presence of pectin appearing in micropyle at time of fertilization.

After fertilization the cell walls of the Malpighian cells modified very rapidly in structure and took stains with difficulty. Chloroiodide of zinc, one week after fertilization, stains brownish yellow except at micropyle where it is blue. In half grown seeds it stains violet at base and brown at outer part of cell. Iodine and phosphoric acid give no distinct stain one week after fertilization. Iodine and sulphuric acid on a mature seed gave a yellowish brown color at outer part of the cells or the region of the cutin and blue in the inner half of the cell, outer half unstained. Cupro-ammonia has little or no action on cell walls. This indicates a cutin on the outside, inner part cellulose, and outer part more impermeable.

Mild hydrolysis was tried. Seeds of three ages were boiled slowly for 20, 50 and 80 minutes in 5 per cent HCl solution with reflux condenser. These were then tested with chloroiodide of zinc. Cell walls all stained deep blue. Cupro-ammonia rapidly dissolved the walls. On mature seeds iodine and sulphuric acid gave a deep blue color with much swelling, on young seeds gave a violet color. This distinctly indicates pure cellulose after treatment for 20 minutes in weak HCl acid solution. Since this substance was so easily hydrolyzed it seems likely to have been a hemi-cellulose. Hemi-celluloses are usually either some paragalactan or pentose. Untreated seed

coats were tested with phloroglucin and HCl acid and then heated to test for a paragalactan substance. No action. This would indicate a pentose substance in the hardest part of the seed coat.

With the above observations in mind, nearly mature and mature white sweet clover seeds which were very impermeable to stains were treated as above with HCl acid solution. When tested with iodine and sulphuric acid and chloroiodide of zinc the domes took a very deep blue color, indicating as in the garden pea the presence of a pentose. The light line and the portion covering the domes were unattacked, except slightly. The light line does not readily yield to hydrolysis.

The work of Coe and Martin was confirmed as to the distance a stain will penetrate a hard seed in white sweet clover. The domes were readily stained to the light line but no trace of stain passed into the light line.

Pammel and others have indicated a light line in Garden Peas in about the position it is commonly found in the *Leguminosae*. Tunmann shows a light line in the shape of a cap over the end of the cell. In this work no distinct light line was observed in the Garden Pea. Testing by immersion in stains showed that the impermeable portion of the pea is in the cutin, since stains do not pass through the cutinized layer.

I wish to express my appreciation of the encouragement and helpful suggestions given me by Dr. J. N. Martin of the Iowa State College while I pursued this work.

SUMMARY

In sweet clover and garden peas the Malpighian layer of cells begins to thicken very much about a week after fertilization. Thickenings are in ridges leaving crevices between.

Sweet clover develops a light line which is more impermeable to water than the outer part of the cell. The pea does not have this region but in some cases had an impermeable cutin.

Pectin is deposited in the cells around the micropyle at about the time of fertilization in the garden pea.

The outer portion of the Malpighian cells of sweet clover and garden peas is a hemi-cellulose, very likely some form of pentose. The inner portion is cellulose.

The impermeable portion of a hard pea seed is located in the cutinized layer as compared with the light line in sweet clover.

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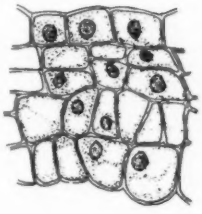
EXPLANATION OF PLATES

Plate 5. Melilotus alba.

Fig. 1. Ovule wall forty-seven hours after pollination and just before fertilization. (x 1500).
Fig. 2. Ovule wall after first division of the egg cell. (x 1500).
Fig. 3. Ovule wall five days after pollination, suspensor well developed. (x 1500).
Fig. 4. Ovule wall six days after pollination. (x 1500).
Fig. 5. Malpighian cells nine days after pollination, cotyledons well developed. (x 1500).

PLATE 5



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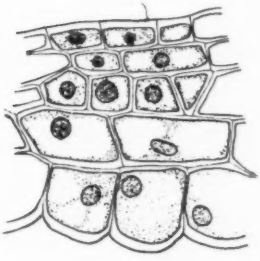

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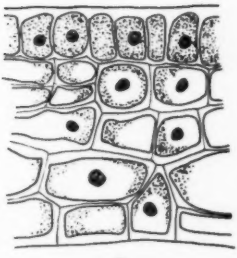

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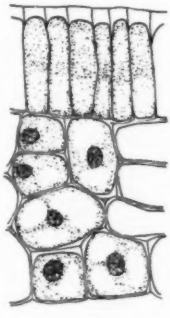

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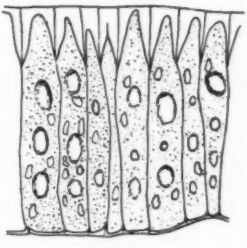

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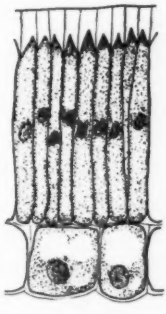

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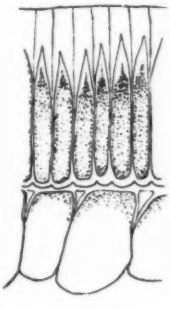

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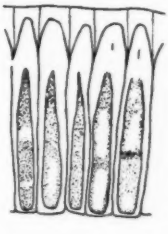

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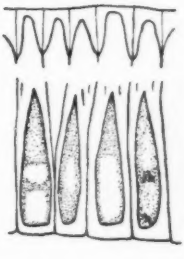

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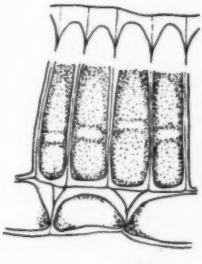

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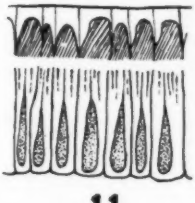

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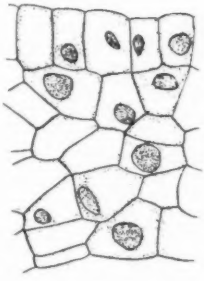
PLATE 6



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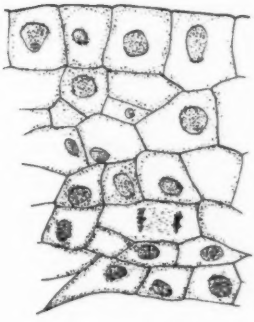

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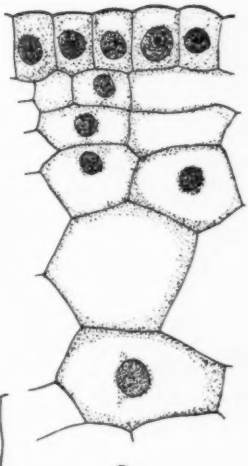

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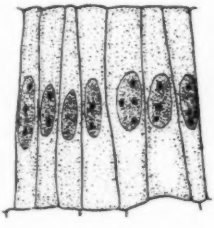

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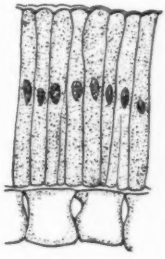

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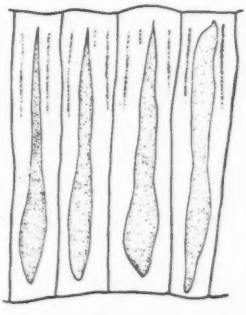

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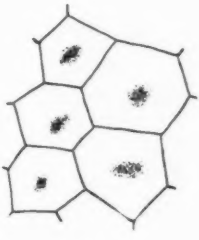

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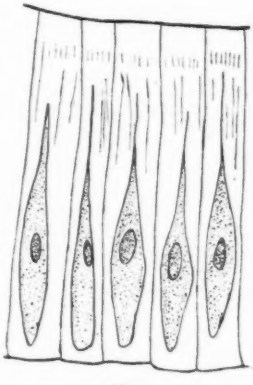

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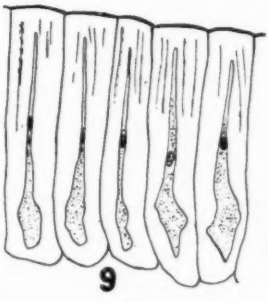

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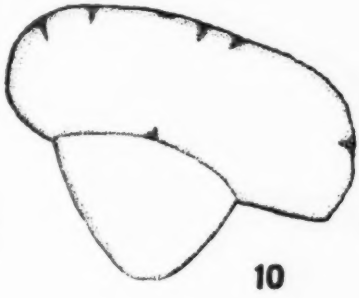

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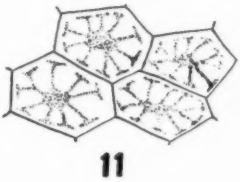

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Fig. 6. Malpighian cells and osteosclerid cells fourteen days after pollination. (x 1500).
Fig. 7. Malpighian and osteosclerid cells sixteen days after pollination. (x 1500).
Fig. 8. Malpighian cells of a medium hard seed showing the first appearance of the light line. (x 1500).
Fig. 9. Malpighian cells of a hard seed with wider light line and smaller proportion of lumen. (x 1500).
Fig. 10. Malpighian and osteosclerid cells of a soft seed, showing narrow light line and large lumen. (x 1500).
Fig. 11. Malpighian cells of a hard seed stained in mass, domes heavily stained but none has passed into or through the light line. (x 1500).
Fig. 12. Cross section through domes. (x 1800).
Fig. 13. Cross section just below the light line. (x 1800).

Plate 6. Pisum sativum.

Fig. 1. Ovule wall before pollination. (x 1500).
Fig. 2. Ovule wall shortly after fertilization. (x 1500).
Fig. 3. Portion of ovule wall about four days after pollination. (x 1500).
Fig. 4. Malpighian cells about ten days after pollination. (x 1500).
Fig. 5. Malpighian and osteosclerid cells about fifteen days after pollination. (x 640).
Fig. 6. Malpighian cells of a mature seed. (x 1500).
Fig. 7. Cross section of Malpighian cells just under the cuticle. (x 1800).
Fig. 8. Malpighian cells of a hard seed, very much reduced lumen. (x 1500).
Fig. 9. Malpighian cells of a soft seed, with lumen extending nearer the cuticle. (x 1500).
Fig. 10. A single Malpighian cell treated with iodine and sulphuric acid. Much swollen, and blue except at triangular shaded portions which are yellow. (x 1500).
Fig. 11. Cross section of Malpighian cells where the lumen appears. (x 1800).

VARIATION OF PROTEIN CONTENT OF CORN

By H. B. Arbuckle and O. J. Thies, Jr.

I. Influence of Climate

Corn is now the greatest feed crop in the United States, and is relied upon for the production of most of the beef, mutton, and pork marketed in this country, and exported to foreign countries. For fattening butcher stock on the farms and in the big feed yards corn is the most efficient food, but for breeding stock, and young animals, it must be used with caution. Grains of higher protein content, such as oats, soybeans, wheat (in form of bran) must supplement the corn.

Many attempts have been made to increase the protein content of corn with a view to removing its deficiency, but despite all these efforts the protein content of corn in general remains the same. By careful seed selection some varieties have acquired the reputation of possessing higher protein content, but after a few years it is found that it has dropped back to its former standard. Hayes and Garber, in 1919, completed some experiments extending through a period of several years, in which, by self-fertilization, followed by crossing and seed selection, they were able to increase the protein content as much as two per cent, thus making it almost the equivalent of oats in protein. The yields, however, were greatly cut down, and the corn developed showed a tendency to revert to the lower protein standard. Such experiments, and other similar observations, raise the question as to whether the protein content in a given variety of corn is a fixed factor.

If the protein does change, can this change be controlled? What is the effect of climate, season, soil, fertilizer, tillage?

The object of this investigation begun a year ago by the authors is to determine, if possible, how certain conditions may modify the protein content in a given variety of corn. This preliminary paper presents the results of our first year's investigation of the effect of climate. We have chosen three varieties of corn, and will supervise the seed selection each year. The first variety is a white corn, Silver King, which has been grown for four years on the farm of

one of the authors in West Virginia. Analysis for three years shows approximately 8.5% protein. This corn has shown little change during these years. It has been grown on the same land under uniform conditions of rainfall and tillage.

The second variety is a white corn of high protein content. The seed was raised in North Carolina, and the corn analyzed was grown in North Carolina. Its protein content is 9.6%.

The third variety is a yellow corn, Golden Dent. This seed was raised in North Carolina, and the corn analyzed was grown in North Carolina. The protein content is approximately 6.7%.

In each case several grains were taken from different parts of a number of ears, and a composite sample was secured by mixing and grinding.

This year we made an analysis of a sample of the first variety, Silver King, secured from ears grown in North Carolina. The seed, however, was raised in West Virginia. It is our purpose to grow this corn, Silver King, for a number of years in North Carolina, reporting results, and also to grow the North Carolina varieties in West Virginia, reporting results.

We were limited in our choice of varieties, as the growing period in West Virginia is only about 110 days.

The altitude at which this corn was grown in West Virginia was 2500 feet. The altitude of Davidson, N. C., where the corn was grown, is 800 feet. The season of North Carolina is approximately 30 days ahead of that in West Virginia. This should furnish such a marked difference in climate that any variation in protein due to this cause should be clearly shown.

Our first experiment showed a marked change in the protein content, but in the direction that is exactly opposite to that generally expected. It has been thought that warmer climates produced higher protein in corn. No satisfactory reason, however, has been given for this supposition. Quite recently it has been shown by a number of experiments that the sugar content has been raised by planting corn in colder climates.

The analyses are given below:

Analysis of the white corn, Silver King, grown in West Virginia.

Percentage of Nitrogen (2 gram sample)	Percentage of Nitrogen (3 gram sample)	Percentage of Protein
No. 1 1.418	No. 4 1.371	8.534
No. 2 1.365		
No. 3 1.376		

Mean, 1.383% N_2

Analysis of the white corn, Silver King, grown in North Carolina.

Percentage of Nitrogen (2 gram sample)	Percentage of Nitrogen (3 gram sample)	Percentage of Protein
No. 1 1.251	No. 4 1.233	7.700
No. 2 1.247	No. 5 1.217	
No. 3 1.213		

Mean, 1.232% N_2

Analysis of the white corn, White Plume, seed raised and grown in North Carolina.

Percentage of Nitrogen (3 gram sample)	Percentage of Nitrogen	Percentage of Protein
No. 1 1.543		9.619%
No. 2 1.531		
No. 3 1.543		

Mean, 1.539% N_2

Analysis of the yellow corn, Golden Dent, seed raised and grown in North Carolina.

Percentage of Nitrogen (3 gram sample)	Percentage of Nitrogen	Percentage of Protein
No. 1 1.095		6.687%
No. 2 1.028		
No. 3 1.087		

Mean, 1.070% N_2

It may be of interest to some to know the method of nitrogen determination employed. After experimenting with several modifications of the Kjeldahl, including the use of potassium perchlorate, we finally adopted as the most satisfactory method of determining nitrogen in corn the following: 3 grams corn, finely ground, is introduced into a Kjeldahl flask, 0.3 gram copper sulphate, C. P. added, and then 20 cc. sulphuric acid with phosphorous pentoxide. After digesting till the material in the flask has assumed a liquid form, 10 grams potassium sulphate, C. P. is added slowly. By this plan samples were completely digested and ready for distillation in times ranging from 26 to 40 minutes. This included five minutes for

digestion after contents of the flask had cleared. We found that the chief factor in the time saving was the introduction of the potassium sulphate at the proper time after the digestion had gotten well under way. This allows the use of comparatively high heat from the beginning without serious foaming of the contents of the flask.

T. B. Osborne, at the Connecticut Agricultural Station, has given us the best data on the protein content of corn and recommends 6.25 as the protein factor. We have used this factor in our calculations. If we succeed in establishing a marked change in the protein, we shall endeavor to show which form of protein found in corn is affected. We append for convenience of reference Osborne's analysis.

Proteins in Corn:

Soluble in Water	Proteose,	0.06%
Soluble in Salt Solution	Globulin,	0.04%
	Maysin,	0.25%
	Edestin,	1.10%
Soluble in Alcohol	Zein,	5.00%
Insoluble in above, but soluble in 0.2% KOH		3.15%

Summary:

1. Plan of investigating influence of climate on protein content of corn is outlined.

2. The analyses of the varieties of corn chosen for experiment are reported.

3. The result of planting of West Virginia grown corn in North Carolina for the first year shows a marked reduction in protein.

4. The modification of the Kjeldahl method which was employed for the determination of nitrogen in corn is given.

DAVIDSON COLLEGE, N. C.

GEOLOGY OF THE MUSCLE SHOALS AREA, ALABAMA

By W. F. Prouty

The Tennessee River at its confluence with the Ohio is the larger of the two streams. The Tennessee represents, about as perfectly as any stream known, a shift of course through successive river capture. Rejuvenation has caused the down-cutting of the Tennessee into its old peneplain. In the neighborhood of Florence, Alabama, where the stream makes a considerable bend toward the north, the older and more resistant rocks of the Nashville arch outcrop and cause the Muscle Shoals, which have a fall of more than 140 feet in the course of a few miles. In the Waldron Ridge the lower part of the Pennsylvanian and upper part of the Mississippian rocks are well exposed. In the Muscle Shoals area proper the lower portion of Mississippian is alone seen along the stream.

In this portion of the State the Fort Payne series is composed of the Tuscumbia limestone above and the Lauderdale chert, limestone and shale below. The very resistant Lauderdale chert forms the bed of the stream throughout the area of the shoals. This rock dips more steeply than the stream so that in going from the head to the foot of the shoals one passes from the bottom to the top of the heavy Lauderdale chert beds. As these beds are jointed, they break off into steps which form the riffles across the stream, usually at a considerable angle to the flow of the stream.

The big or Wilson dam, now under construction, is located near the foot of the shoals and near the top of the Lauderdale chert. At this locality the river runs south of west, the 4000 foot dam runs a little west of north and the dip of the formations is practically due south. At this point the dip is unusually large, being about 60 feet for the width of the river. As a result of this the bed of the stream and the north bluff are composed entirely of the Lauderdale chert formation while the bluff at the south end of the dam is made up in part of the less resistant chert of the Lauderdale, and at higher levels of the more soluble limestone of the Tuscumbia formation. It is in the portion of the proposed flooded area occupied by this more soluble limestone that trouble from leakage is anticipated and it was

because of this threatened leakage that the writer was asked to make a geological report to the Government concerning the dam foundation during the war period.

Although there is a considerable area of the Tuscumbia which will be flooded by the Wilson dam, the trend of the rocks is such that no great danger from leakage is to be expected except in the area near the dam, where considerable pressure grouting will be necessary.

The proposed Dam No. 3 is to be located near the head of the Big Muscle Shoals. At this point the Lauderdale chert occupies the southern bluff while a shale and a very soluble crinoidal limestone, lying below the Lauderdale chert, occupy the northern portion of the stream bed and the northern bluff. At this locality the northern end of the proposed dam is the weak one and the weakness is of greater concern than at the south end of the Wilson Dam.

The strata throughout the area show a number of small, rather sharp folds. These run nearly with the strike. One such fold is seen in the bed of the stream near the north end of the Wilson Dam. It does not here constitute a line of weakness. Another such sharp fold cuts diagonally across the river at Bainbridge Eddy, here bringing up the less resistant shale and limestone which have yielded the deep and narrow channel.

The upper Lauderdale in places contains small cavities containing oil residues. That gas is also present, in small amounts at least, is also demonstrated by the secondary explosions which were so common following blasts made at the location of the new power plant on the south side of the river below the Wilson Dam.

CHAPEL HILL, N. C.

AZALEA IN NORTH CAROLINA

By W. W. Ashe

Key to Eastern Species following that of Small's Flora of the Southeastern United States. Only the species in italics in the key are known to occur in North Carolina.

Corollas expanding with or before the leaves
  Corollas red or orange or yellow
    Flowers with the leaves
      Corolla tube glandular outside.....(1) *A. calendulacea* Mx.
      Tube merely pubescent outside.....(2) A. speciosa Willd.
    Flowers before the leaves.....(3) A. austrina Small
  Corollas white, pink, or purplish
    Low stoloniferous shrubs, under 5 dm. high
      Flowers white, tube glandular, funnel-form.....(4) *A. atlantica* Ashe
      Flowers purplish, only back of lobes glandular, tube cylindrical
        (5) *A. neglecta* Ashe
    Not stoloniferous, more than 5 dm. high
      Leaf blades pubescent beneath
        Corolla tube pilose, dilated above middle
          Leaves not glaucescent under pubescence
            (6) *A. rosea* Lois.-Desl.
          Leaves glaucescent under pubescence (7) A. alabamensis* n. c.
        Corolla tube villose, apex abruptly expanded (8) *A. canescens* Mx.
      Leaf blades strigose only on midrib beneath.....(9) *A. nudiflora* L.
Corolla expanding after the leaves
  Leaf blades glabrous beneath or with scattered hairs (except var. of (10)
    Midnerve strigose beneath at maturity.....(10) *A. viscosa* L.
    Midnerve glabrous at maturity
      Leaves serrulate.....(11) A. serrulata Small
      Leaves with ciliate margins
        Corolla glandular pilose.....(12) *A. arborescens* Pursh.
        Corolla nearly glabrous.....(13) A. prunifolia Small

Azalea speciosa should be looked for in North Carolina near the base of the Blue Ridge between Jackson and Polk counties.

The following varieties have been reported from or should be looked for in North Carolina:

A. nudiflora glandifera Porter. It has the pedicels and corolla tubes more or less glandular pubescent.

* *Rhododendron alabamense* Rehd. Azal., 141. 1921.

A. atlantica luteo-alba Coker. It is distinguished by its finely pubescent leaves.

A. viscosa glauca Ait. It differs from the type in its glaucus leaves. It should occur in the coastal plain.

A. viscosa tomentosa Hort. (*A. tomentosa* de G. Bot. Cult., 2nd. ed., **3**: 336. 1811). This has the leaves more or less pubescent. (Cumberland Co., near Manchester).

A. viscosa hispida Wood. The branchlets are hispid. It has not been found south of Pennsylvania but might occur in mountain swamps in North Carolina.

A. viscosa montana n. c. (*Rhododendron v.* var. Rehd. Azal., 164. 1921). This has been found only in the mountains of North Carolina. It differs from the type chiefly in the pubescent winter buds.

A. arborescens Richardsonii n. c. (*Rhododendron a.* var. Rehd. Azal., 168. 1921). This is a shrubby form which occurs on the summits of high mountains in North Carolina.

The following varieties which have been reported from further south do not occur in North Carolina:

A. canescens candida n. c. (*Azalea candida* Small. Bull. Torr. Bot. Club **28**: 360. 1901). Differs from the type in the glaucescent and densely pubescent leaves.

A. serrulata georgiana n. c. (*Rhododendron s.* var. Rehd. Azal., 156. 1921). This differs from the type chiefly in its densely pubescent winter buds.

A. viscosa aemulans n. c. (*Rhododendron v.* var. Rehd. Azal., 165. 1921). This variety, which has been found only in Randolph County, Georgia, differs from the type chiefly in its larger leaves.

NOTE ON RHODODENDRON—During the past year considerable additional information has been secured concerning the two small early flowering rhododendrons of the southern Appalachians. *Rhododendron carolinianum* Rehd., the rose flowered plant, is not uncommon, particularly on dry standstone sites, in North Carolina and Tennessee to the north of the French Broad river valley. To the south of this valley, and particularly to the south of Mill Creek along the Blue Ridge at relatively low altitudes on moist cool sites, occurs the white flowered plant, *Rhododendron Margarettae* n. c. (*R. carolinianum* var. *Margarettae* Ashe, Rhod. **23**: 177. 1921) which on account of its different habitat and distinct distribution can probably best be regarded as specific.

FOREST SERVICE,
WASHINGTON, D. C.

NOTES ON THE REPRODUCTION OF HYDRA IN THE CHAPEL HILL REGION

By H. S. Everett

In the course of an investigation dealing with the germ cells of *Hydra* during 1920-1921, a number of observations were made on the occurrence and habits of hydras in the region around Chapel Hill. The work continued over a period from October until June, and it is the purpose of this article to record briefly such data as may be of general use and interest to the worker on *Hydra* in the Chapel Hill region.

Two species, *H. viridis* and *H. grisea*, were found throughout the period in collections of leaves trash, and green algae from pools and swamps near the town. In the spring they occurred in much greater abundance out of doors than in the fall and winter.

H. grisea was always found budding vigorously, but showed no sex organs until late in May, when some specimens which had remained in aquaria in the laboratory for about two weeks developed gonads. Although green hydras were not found in a sexual state out of doors until April, animals could be found in the laboratory with gonads at nearly all seasons. This species *(H. viridis)* appeared in three aquaria, the material of which was collected early in October. The hydras underwent a period of vigorous budding, after which about the first of December large numbers developed sex organs. This sexual period lasted about a month. After it had ceased the animals in two of the aquaria seemed to be well-nourished and continued to bud for some months, but never returned to the sexual state. Those in the third aquaria seemed to be underfed, budding practically ceased, and they began to grow smaller. A careful examination of them about February the first revealed the fact that eighty-two per cent of them possessed male sex organs. This observation was in complete agreement with the statement often made that the spermaries are produced as a result of starvation. But though this may be one stimulus for the production of the sperm, it is certainly not the only one, at least in *H. viridis*, for the ovaries are never

found without the spermaries also, and the ovaries are found only in well-fed animals.

The period, then, most favorable to sexual reproduction in *Hydra* in this region begins in April and continues through May, and since no cessation was noted at the time observations were discontinued, we may conclude that it probably extends on into the summer.

The course of the development of the egg in *Hydra viridis* was followed in some detail. The egg arises from numerous ordinary interstitial cells, which first enlarge beneath the epithelial ectoderm and then coalesce to form a single egg. One nucleus persists as the egg nucleus, the rest degenerate. The coalescence is at first by simple fusion of the central cells to form a large central mass, which then ingests the peripheral cells in an amoeboid fashion.

My observations are in general accord with those of Jannreuther (Biological Bulletin **14, 16**) and Wager (Biol. Bull. **18**).

The subsequent development has been often described and is well known. The time required for the development of the egg until its extrusion through the ectoderm is about four days, while about three weeks are consumed after the extrusion through the ectoderm before the young hydra is hatched. These observations were made on animals kept in laboratory vessels where it was also found that the number of extruded eggs which fail to develop either from non-fertilization or other causes is very large. It was not possible to determine whether these same facts hold for the out-of-door environment.

CHAPEL HILL, N. C.

CHEMISTRY IN ITS RELATION TO THE STATE WATER SUPPLIES

By G. F. Catlett

Twenty years ago in comparison to the possible development the chemist and applied chemistry were utilized very little in solving industrial problems. It has been interesting and gratifying to observe how the utilization of the chemist has broadened until in recent years most large corporations and big industries have their own research laboratories and control by chemists over their processes and raw material.

In the field of municipal utilities the late Dr. Baskerville in his book "Municipal Chemistry" has covered very fully how chemistry is concerned very essentially in most all of our municipal activities. In particular may be mentioned water supply and water purification, sewage disposal, waste and garbage disposal, gas supply, quality of materials such as cement and paving materials. While the application of the chemical data, except in very large organizations, is usually made as part of the work of the sanitary engineer, the solution of the chemical problems must rest with the chemist.

Almost as far back as the history of the science dates the chemists have developed analytical methods and made investigations that cover the properties and quality of natural waters for domestic and industrial uses.

As the cities and town have grown and the population has collected in more or less congested groups, it has become necessary, in North Carolina as elsewhere, to utilize sources of water supply which require very elaborate purification to render them suitable for domestic and industrial purposes. It has also been necessary to devise treatments of sewage and wastes in order to prevent their contaminating these public water supplies.

North Carolina now has over fifty towns and cities where it is necessary to filter and purify an unacceptable surface water in order to obtain a suitable public drinking supply. In general only the very smallest towns are able to utilize natural underground water supplies, and even those frequently require chemical sterilization. As

the towns grow the number of purification plants are rapidly increasing.

Almost the universal method for purification is the so-called mechanical or rapid sand filtration involving the coagulation of the water with aluminum hydrate and the preparation of a film of this chemical as a medium through which the water is filtered. In conjunction with this is chemical sterilization with chlorine. These processes are basically chemical ones, and difficulties encountered in their use must be largely solved through chemistry. The mechanical features in both cases have been very highly developed, and such lack of efficiency as is found is chiefly due to the chemical features.

When mechanical filtration first began to be utilized aluminum sulphate (commonly called filter alum) was used and the hydrate serving as coagulent prepared by adding soda ash sufficient to react with the aluminum sulphate required and to furnish sufficient excess to insure complete precipitation of the alum.

While the process was in general recognized as a success, different waters reacted differently using the same amount of chemicals, and on the same type of water poor coagulation was frequently experienced and in many cases the reaction involved did not complete itself until after passing the filters with precipitation in the water mains. These troubles were experienced particularly in the case of waters with considerable vegetable stain such as are found in eastern North Carolina.

About the year 1915 several engineers, including the writer, called attention to the fact that what was involved in the whole process was so-called "colloidal chemistry." It was well recognized that aluminum hydrate was precipitated in colloidal condition and its coagulation followed the known action of such physical condition. The finely divided clay and organic matter was obviously in colloidal condition, and Thorndike Saville, working in the Harvard Laboratory, proved that the vegetable coloring matter was in colloidal suspension. It was also determined that the clay was negatively charged and aluminum hydrate and coloring matter positively charged. It was suggested that the proper application of aluminum sulphate and the ratio of this to alkali present was one of ionization balance.

Due largely to the fact that "colloids" and "ions" represented something surrounded by impenetrable mystery to the average engi-

neer and water works man, a proper investigation of the matter has been very slow to start. During recent years, however, a great deal of interest has been awakened, and we find no convention of water works people whose program does not include at least one paper on hydrogen ion determination in the control of water treatment. Quite a little work is being done on the subject in various parts of the country and with recent development of simple methods for determining hydrogen ion concentration value, the outlook is good for some valuable data of practical value. At present there is very little useful information developed regarding the whole matter.

Another problem, entirely a chemical one, is trouble experienced in the corrosion of mains and plumbing or the deposition of incrustants in these mains. With the natural waters we felt as if we knew the causes of this and remedies. With the chemical and physical condition of the water disturbed by the artificial means employed for purification, the matter is very much complicated. Such data as has been collected would indicate that the hydrogen ion concentration figures would solve this difficulty. The field at present, however, has been very little explored, the most important contribution to the subject being a very interesting paper by some Dutch chemists. In the case of chlorine sterilization the chief difficulty is to prevent chemical combination of the chlorine with waste by-products causing tastes and odors.

A fourth very important state problem, which we must look chiefly to our chemists to solve, is the interference with sewage disposal plants by dye house wastes. From various parts of the state we are having complaints of the functioning of municipal sewage disposal plants being entirely or partially destroyed by dye house wastes from textile plants. The chief trouble seems to be from bleach, sizing, and dyestuffs, of which the sulphur blacks seem to be the worst offenders. If we cut these out of the municipal sewerage and deposit in some adjacent small stream a nuisance is the usual result. The problem is how to treat these wastes so as to render them non-injurious to the disposal plant process, or how to change the disposal plant process so as to handle them, or else how to treat them separately and secure disposal without nuisance.

Upon inquiry there seems to be little information developed in other parts of the country in regard to the matter, chiefly because most of the textile communities that might have investigated have

larger streams for disposal than in our state. North Carolina, as you are aware, is a leading textile state and the problem is one of importance to us and of general interest.

Some of the other states, notably Massachusetts, have contributed to a large extent to our knowledge of such subjects, largely through coöperation with their institutions of learning, through State Departments and the scientist concerned. There are certain features of the problems cited, especially in regard to the treatment of colored waters and the textile waste, which are peculiarly North Carolina problems.

These problems have been brought to your attention with the hope that the chemists may interest themselves in their solution. If it is not possible to do actual work upon them, the clearer understanding of such problems by virtue of chemical knowledge will put the chemist in better position to influence coöperation in their solution. There are no state funds available at present for such work, but the Department of Engineering at the University has offered to coöperate and the State Board of Health through its various bureaus concerned is always willing to lend any assistance in its power.

RALEIGH, N. C.

THE LACCARIAS AND CLITOCYBES OF NORTH CAROLINA

By W. C. Coker and H. C. Beardslee

Plates 1 and 7-33*

Laccaria

Cap fleshy, thin, usually depressed or umbilicate in center; gills thick with blunt margin, broadly adnate, in our species usually notched at the stem (sinuate), colored conspicuously, whitened by the abundant spores which are subglobose, white or faintly lavender, and echinulate; stem central, fibrous and toughish. Volva and veil wanting. Gregarious or cespitose. Our four species of this genus are very closely related, so much so that certain authors (Rieken, Die Blätterpilze **2**: 382. 1915) consider *L. laccata*, *L. amethystea* and *L. tortilis* all forms of the same species, and from our observations in several sections of the country it is impossible to define any one of these three species so as to exclude forms of the others. In the vicinity of Chapel Hill we find that *L. laccata* can be distinguished usually by its thinner, closer, less irregular gills which are nearly always paler than in the other two, where the variations are more confusing.

The genus differs from *Clitocybe* in the globose, asperulate spores and thicker gills which are more broadly attached, often sinuate and not decurrent except by a little tooth. The attachment of the gills is about as in *Tricholoma*, but that genus is separated by thinner gills and different spores. In *L. ochropurpurea*, *L. amethystea* and *L. tortilis* the mature gills are conspicuously white-dusted by the spores, but in the commonest forms of *L. laccata* this character is not well shown.

Important American Literature

Kauffmann. Agaricaceae of Michigan, p. 747 (as *Clitocybe*). 1918.

Morgan. Journ. Cincinnati Soc. Nat. Hist. **6**: 66 (as *Clitocybe*). 1883.

Murrill. N. Am. Flora **10**: 1. 1914.

Peck. Bull. N. Y. St. Mus. **157**: 90. 1912.

* In the colored plate, figures 1, 6 and 7 were painted by Miss Dorothy Coker, figures 2 and 5, by Miss Cornelia S. Love and figures 3 and 8, by Miss Alma Holland. All spore drawings are by Miss Holland. Unless otherwise stated photographs are by Coker and are natural size. Those by Beardslee are noted "Photo by B." The written matter is by Coker unless otherwise stated.

PLATE 7

LACCARIA OCHROPURPUREA. No. 641.

KEY TO THE SPECIES

Plants usually more than 5 cm. broad.....*L. ochropurpurea* (1)
Plants less than 5 cm. broad
  Cap not marked by lines; plants larger than *L. tortilis*
    Gills pinkish lilac.....*L. laccata* (2)
    Gills deep violet-purple.....*L. amethystea* (3)
  Cap distinctly striatulate; plants small; growing in wet places.....*L. tortilis* (4)

1. **Laccaria ochropurpurea** (Berk.) Peck.

PLATES 7 AND 33

Cap 6-13 cm. wide, almost smooth or slightly scaly, often irregular and contorted, bright tan or clay color with a very light tint of pink from the flesh which is light pink, thick in the center and thin on the margin.

Gills purplish-lilac, changing to grayish purple and powdered by the spores, distant, very wide, thick, wavy and irregular, usually sinuate and slightly decurrent by a tooth.

Stem stout, usually crooked, variable in length and thickness, tough and firm, solid, color of cap, longitudinally marked with pinkish fibers.

Spores (of No. 1311) globose, minutely asperulate, 6.8-8.5μ in diameter. A thick spore print of No. 4675 shows a decided tint of pale lavender like the gills.

Not rare in uplands along banks, roads and margins of woods.

For other illustrations see Peck, Bull. N. Y. St. Mus. **116**: pl. 106, figs. 7-11. 1907; McIlvaine, Am. Fungi, pl. 24, figs. 1-4. 1900; Hard, Mushrooms, pl. 11.

100. In Battle's Park, October 8, 1904.
179. In mixed woods near creek, Glen Burnie Farm, October 1, 1908.
181. Under log in damp ground, October 1, 1909.
641. From under the sides of rocks by a road, October 28, 1912.
761. Along "Fern Bank," September 14, 1913.
1311. By road through deciduous woods, October 7. 1914.
4675. Mixed woods near Pittsboro road, October 15, 1920. Spores pale lavender, spherical with sharp straight mucro, minutely echinulate, 7.2-9.5μ thick.

Asheville. Rather common. Beardslee.

2. **Laccaria laccata** (Scop.) Berk.

PLATES 1, 8 AND 33

Cap about 3 cm. broad on the average, running up to 6.5 cm., deeply depressed in center and often irregular and split, hygrophanous, surface light tan or reddish buff or buffy cinnamon when not soaked, a deeper reddish-ochraceous when soaked, rarely striatulate, squamulose-scurfy or only somewhat channelled and fibrous. Flesh very thin, tough and elastic, a light pink color, taste slightly woody, odor none.

Gills broad, up to 1.2 cm. wide, not crowded, sub-distant or distant, thickish and wavy, entire, or at times fragmented and irregular, notched at the stem, slightly decurrent by a tooth, pinkish with a tint of lilac.

Stem 2.5-9 cm. long, 3-6.5 mm. thick, sub-equal or irregular, at times bulbous, hollow, tough, elastic, fibrous, color of cap with a tint of flesh.

Spores (of No. 854) spherical, echinulate, 6.6-7.6μ in diameter not including the spicules. Basidia (of No. 5118) 7.4-8μ thick, 4-spored; hymenium about 48μ thick, with a few crystals; threads of the gill flesh 3.7-7μ thick, constricted at the septa, and parallel in section.

The species is common in pine and not rare in deciduous woods, growing often in populous colonies and sometimes in fairy rings. It is distinguished from *L. tortilis* by stouter form, thinner, closer and more regular gills, usually non-striate cap, and preference for upland woods. It differs from *L. amethystea* in absence of deep purplish color and thinner, closer and more regular gills.

For other illustrations see Cooke, Ills. Brit. Fungi, pl. 139; Hard, Mushrooms, figs. 76 and 77; McIlvaine, Am. Fungi, pl. 24, fig. 10. 1900; Murrill, Mycologia 3: pl. 40, fig. 4. 1911; Peck, Rept. N. Y. St. Mus. 48: pl. 25, figs. 1-13. 1895.

854. Growing abundantly in a large fairy ring about twenty feet in diameter under pines, September 18, 1913.

1413. Under pines near Piney Prospect, October 24, 1914.

1435. Under pines near Piney Prospect, October 28, 1914. Spores spherical, echinulate, 6.8-7.6μ.

1495. Under pines, Glen Burnie Farm, December 8, 1914.

2960. On ground in pine woods, December 3, 1917.

2993. On ground in pine woods, March 25, 1918.

3176. Low place in deciduous woods east of cemetery, October 3, 1918. Spores 6.3-8.5μ thick.

PLATE 8

LACCARIA LACCATA. No. 854.

3181. Among pines near branch southeast of campus, October 5, 1918. Spores white, spherical, papillate, 7-9μ.

3246. By branch in deciduous woods, Lone Pine Hill, May 25, 1919. Spores 7-9.3μ thick.

5118. By branch south of campus, May 19, 1922. Typical. Spores spherical, minutely spinulose (less so than in *L. tortilis*), 6-8.2μ thick.

Asheville. Very common. Beardslee.
Blowing Rock. Atkinson.
Reported by Curtis.
South Carolina: Hartsville. In pines and in a field, December 26, 1918 (No. 72. W. C. Coker, coll.).

3. **Laccaria amethystea** (Bull.) Murrill.

PLATES 1 AND 33

Cap 1-5 cm. broad, irregularly crumpled and lobed, in age the margin uplifted or reflexed; the center depressed or plane; surface like rougish leather, the margin finely scaly, not squamulose all over as typically in *L. laccata*, color when not soaked avellaneous to vinaceous buff (Ridgway); when young and when soaked almost as purple as the gills, the margin retaining the purple longer. Flesh very thin, up to 1 mm., toughish, concolorous, taste and odor musty-fungoid.

Gills distant, thick and leathery, up to 3.3 mm. thick, irregular, broadly adnate and decurrent by a tooth, color at all ages deep violet purple (about dull Indian purple of Ridgway), at maturity dusted with the spores.

Stem 3-5 cm. long, 2-5 mm. thick, sub-equal or enlarged below or above, crooked, tough, color of cap or whitish with a scurfy surface; in youth purple; stuffed then hollow.

Spores white, spherical, minutely spinulose, 7-10μ thick. Basidia 5.5-8.5μ thick, 2-4 sterigmata. Hymenium 48μ thick, with many crystals. Threads of the gill flesh 3.7-8μ.

In damp places in woods; rather rare. This plant has been considered a species or a variety or only a form of *C. laccata*. Peck treats it as a good species, Kauffman as a variety and Ricken as only a form. Careful comparison in the fresh state of this and the common form of *C. laccata* shows the latter to differ in broader, thinner, less distant and notched gills of a pinkish-lilac (much paler) color, cap more squamulose and buffy-cinnamon in color. For other illustrations of *L. amethystea* see Mycologia **10**: pl. 8, fig. 2. 1918;

Bulliard, Herb. Fr., pl. 198; Bolton, Hist. Fung. Halifax, pl. 63. 1788.

3622. In pine woods by Bowlin's Creek, November 9, 1919.
5046. Among moss on side of stream, May 8, 1922.
5119. On earth by ditch in deciduous woods, May 19, 1922.
5178. By branch south of campus, June 6, 1922.

Asheville. Occasional. Beardslee.

4. **Laccaria tortilis** (Bolt.) B. & Br.

PLATES 1, 9 AND 33

Caps usually irregular, often cespitose, 0.5-2.3 cm. broad, rounded or nearly plane to depressed in center, usually slightly unbilicate, nearly smooth or minutely fibrous roughened, hygrophanous, and, when water-soaked, of a dull fleshy-brick color with a distinctly deeper-colored line over each gill (striatulate); when dry pale fleshy buff and not striatulate or very faintly so. Flesh colored like the surface, brittle, very thin and translucent, only one-third mm. thick near stem; taste rather nutty.

Gills broadly adnate, usually sinuate, sometimes squarely attached, very slightly decurrent, distant, thick, irregular, the margin blunt, deep flesh color and distinctly powdered with the white spores.

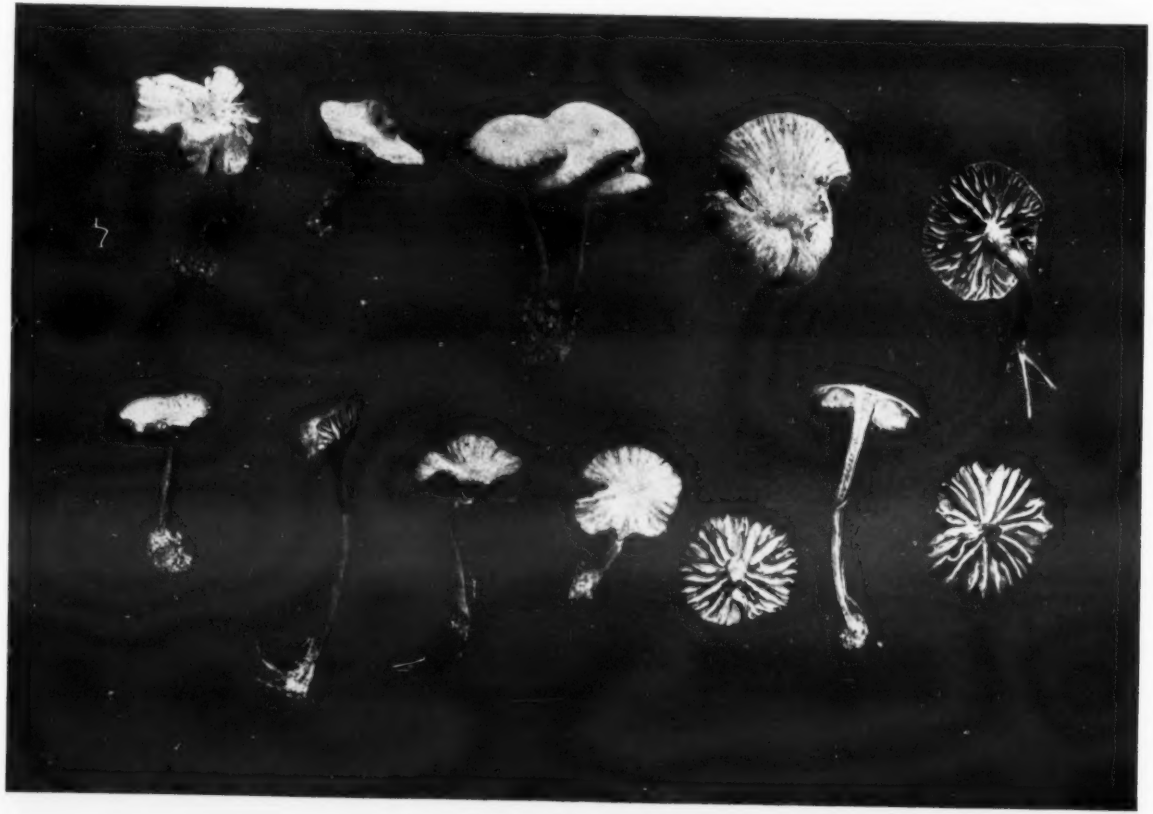
Stem 1.2-3.5 cm. long, 1-2 mm. thick, equal, often twisted and bent, sometimes flattened; surface pruinose, flesh tough, fibrous, a small hollow, color of cap, the base often somewhat swollen and at times white with mycelium.

Spores white, spherical, echinulate, 7.4-10.3μ, (up to 11μ, counting the spines) usually about 9.2μ in diameter. Basidia (of No. 5121) 9.7-12.5 x 30-37μ with 4 long, curved sterigmata.

Frequent in damp depressions in woods and along wet ditches. The spores of our plant are smaller than the dimensions given by Peck, but they are distinctly echinulate and also very variable in size in the same plant. The striatulate cap, small size, irregular shape, thick distant and leathery gills, large spores and swampy habitat would indicate this species. Patouillard describes and figures the basidia as two-spored (see below). They have not been so in the plants we have examined.

For other illustrations see Mycologia **10**: pl. 8, fig. 4 (as *L. striatula*). 1918; Bolton, Hist. Fung. Halifax, pl. 41. fig. A (as *Agaricus tortilis*). 1788; Patouillard, Tab. Fung., No. 105.

PLATE 9



LACCARIA TORTILIS. No. 1954.

1951. In grass in moist place in Arboretum, November 1, 1915.
2454. Swamp of New Hope Creek, September 28, 1916.
2886. Swampy woods near Strowd's pasture, October 8, 1917. Spores spherical, echinulate, 7.4-10μ thick, not counting spines, 8.4-11μ counting spines.
3199. Low place with moss, October 7, 1918. Spores 7.4-9μ thick.
3344. In moss by creek below Glen Burnie Farm, June 11, 1919. Spores 7-10μ thick.
3612. Damp ground near swamp, Strowd's low grounds, November 8, 1919. Cap 5-13 mm. broad, almost glabrous, striate when moist, deep reddish-ochraceous.
5121. On earth by branch south of campus, May 19, 1922. A very small lot; gills sometimes decurrent, spores spherical, spinulose, 7.7-10.5μ thick.

Asheville. Rare, usually in damp places. Beardslee.

CLITOCYBE

Cap mostly depressed in center or infundibuliform, the margin involute to near maturity. Gills narrowed toward the stem, typically decurrent, but often only slightly so and rarely they are even a little notched at the stem. Stem fibrous externally, more or less elastic, not brittle, sometimes hollow, continuous with the flesh of the cap. Spores typically white, but flesh color in *C. cerussata* and tinted pinkish-lavender in *C. cyathiformis*, elliptic, pip-shaped or rarely subspherical, smooth in all species here included, said to be minutely echinulate in *C. pulcherrima*, *C. albissima* and *C. maxima*. Volva and annulus wanting. Growing on the ground or among leaves or on rotting wood. One species, not yet found here (*C. nebularis*), is the host of a parasitic *Volvaria* (*V. Loweiana*. See Mycologia **8**: 65. 1916) and another (*C. peltigerina*) grows on the lichen *Peltigera*. This is not always an easy genus to determine as the gills are variable, in some cases approaching *Tricholoma*, in others *Collybia* or *Omphalia*. A few of the species are poisonous, as *C. illudens* and *C. morbifera*, but these are not classed among the deadly mushrooms. *Clitocybe sudorifica* causes profuse perspiration.

IMPORTANT AMERICAN LITERATURE

Kauffmann. Agaricaceae of Michigan, p. 715. 1918.
Morgan. Journ. Cincinnati Soc. Nat. Hist. **6**: 66. 1883.
Murrill. N. Am. Flora **9**: 396. 1916; Mycologia **7**: 256, pls. 164-166. 1915.
Peck. Rept. N. Y. St. Mus. **23**: 75. 1872. Bot. ed. Also Rept. **157**: 59. 1912.

KEY TO THE SPECIES

Plants growing from bases of stumps or from underground wood; densely cespitose and usually large
Plant brownish or honey-colored.....*C. tabescens* (3)
Entire plant orange colored.....*C. illudens* (5)
Plants not wood-loving, or if so not densely cespitose and smaller
Plants with a distinct odor of sweet fennel or anise
C. odora var. *anisaria* (14)
Not with an odor of sweet fennel
Gills golden yellow; cap fibrous lined.....*C. ectypoides* (15)
Gills not golden yellow
Cap white or tan or buff or fleshy-buff (see also *C. infundibuliformis*)
Cap large, up to 7-11 cm. broad
Gills broad, margin of cap lobed or crenate.....*C. gigantea* (1)
Gills narrow, crowded, margin of cap even; plants strongly cespitose.....*C. cerussata* (4)
Cap smaller
Cap marked by more or less concentric rivulose lines..*C. rivulosa* (20)
Cap not so marked
Growing in open grassy places, cap light buff or fleshy-buff.....*C. dealbata* (19)
Growing in woods among leaves and sticks, or on much decayed wood
Growing among pine needles.....*C. pinophila* (17)
Not growing in pine woods
Stem base with radiating hairs; spores 2.7-3 x 3.8-4.2μ.....*C. setiseda* (18)
Stem base without hairs.....*C. adirondackensis* (11)
Cap chestnut red or reddish when young, often ochraceous or lighter in age
Center of cap cracked into minute, inherent scales *C. sinopicoides* (10)
Center not cracked.....*C. infundibuliformis* (9)
Cap blackish-brown or grayish-brown or grayish buff or umber or drab when moist
Taste and odor strongly farinaceous, the cap brown or smoky
Stem long, white below.....*C. cyathiformis* (16)
Stem shorter, not white below.....*C. subnigricans* (8)
Taste and odor not farinaceous
Strongly cespitose, usually with stems fused below into a solid mass
Cap grayish-brown to sordid brown.....*C. tumulosa* (6)
Cap smoky gray to nearly white.....*C. conglobata* (7)
Not strongly cespitose
Gills very narrow, not over 2 mm. wide.....*C.* sp. (2)
Gills over 3 mm. wide
Stem base much swollen.....*C. clavipes* (12)
Stem base not swollen.....*C. media* (13)

1. **Clitocybe gigantea** Sowerby.

Paxillus giganteus (Sow.) Fr.

PLATE 10

Solitary or gregarious; cap up to 11 cm. wide, depressed in center, the margin incurved when young, drooping at maturity, usually very irregular and much lobed; surface whitish to light tan or buff, darkest in center, smooth or somewhat pruinose in angles. Flesh white, soft, mild.

Gills not crowded in our plants, irregular, thick, wide, up to 8 mm., many short ones, none forked, decurrent, but ending abruptly and bluntly and therefore somewhat resembling a *Tricholoma*. The gills are slow to develop and in young plants are very narrow.

Stem short, about 5 cm. long, 1.5-2 cm. thick, the outer part fibrous, the inner softer and often cavernous, usually bent at base; surface smooth, color of cap, pure white at the very top.

Spores white, smooth, elliptic, 3.5 x 5-6μ.

A peculiar plant that is not closely related to other species of *Clitocybe*. It is said to reach a breadth of over a foot. The thick and irregular gills remind one of a *Paxillus*, but they do not separate easily from the cap.

This agrees well with *C. gigantea* in the sense of Kauffman except that the gills are not very crowded. Ricken does not give the spores.

For other illustrations see Gillet, Champ. Fr., pl. 124 (100); Quélet, Champ. Jura et Vosg. 1: pl. 3, fig. 3. 1872; Cooke, Ills., pl. 106; Juillard-Hartmann, Icon. Champ. Sup., pl. 31, fig. 5.

1765. Low damp woods near pines at foot of Lone Pine Hill, September 12, 1915.
1832. In woods loam by branch south of Raleigh road, Rocky Ridge Farm, September 20, 1915.

Asheville. Rare. Beardslee.
Reported by Schweinitz.

2. **Clitocybe** sp. ?

PLATES 11 AND 33

Cap 4-13 cm. broad, broadly depressed in center, the margin plane or crimped and drooping, surface quite glabrous, sub-shining, viscid when wet; color buffy drab, between drab and wood-brown of

Ridgway. Flesh white, only up to 1 cm. thick at stem, very thin toward margin, pliable, taste mild and sweetish, odor faint.

Gills crowded, very narrow, hardly up to 2 mm. wide, fading to a line toward the stem and barely reaching it; color exactly that of the cap.

Stem 2-4.5 cm. long, 1.3-1.8 cm. thick, color and surface of cap, solid, soft and pliable, the base sub-bulbous.

Spores white, smooth, sub-elliptic to pip-shaped, 2.2-3 x 4-5μ.

A peculiar plant, sharply marked by the uniform gray-buff color, soft, tough flesh and peculiar gills. In the absence of young stages and with only one collection we prefer not to name it as yet. It may possibly be a form of *C. nebularis*, but a plant of that species from Peck has gills broader and much darker in the dried state. It cannot be *C. geotropa*. In his Funghi Mangerecci, pl. 39, Bresadola shows an obviously different plant and the spores are nearly globose and rough. A plant from his herbarium, so labelled, has spores that are rough, but they are 3.7-4.6 x 5-7μ and are not like those of our plant. Ricken gives the spores at 5-6 x 6-7μ and does not mention roughness. *Clitocybe geotropa* is also recognized as being a paler plant than ours and as being umbonate or gibbous and it could hardly be brought to the thinness in center shown by No. 3210. (See Bresadola as cited above; Ricken, pl. 101, fig. 1; Bulliard, pl. 573; and Dumée, Atlas Champ., Ser. 2, pl. 15). *Clitocybe lenticulosa* Gill. is also easily different, with its rough cap and white, long decurrent gills (Champ. Fr., p. 144, pl. 130).

3210. In sandy humus near branch west of Meeting of the Waters, deciduous woods, October 9, 1918.

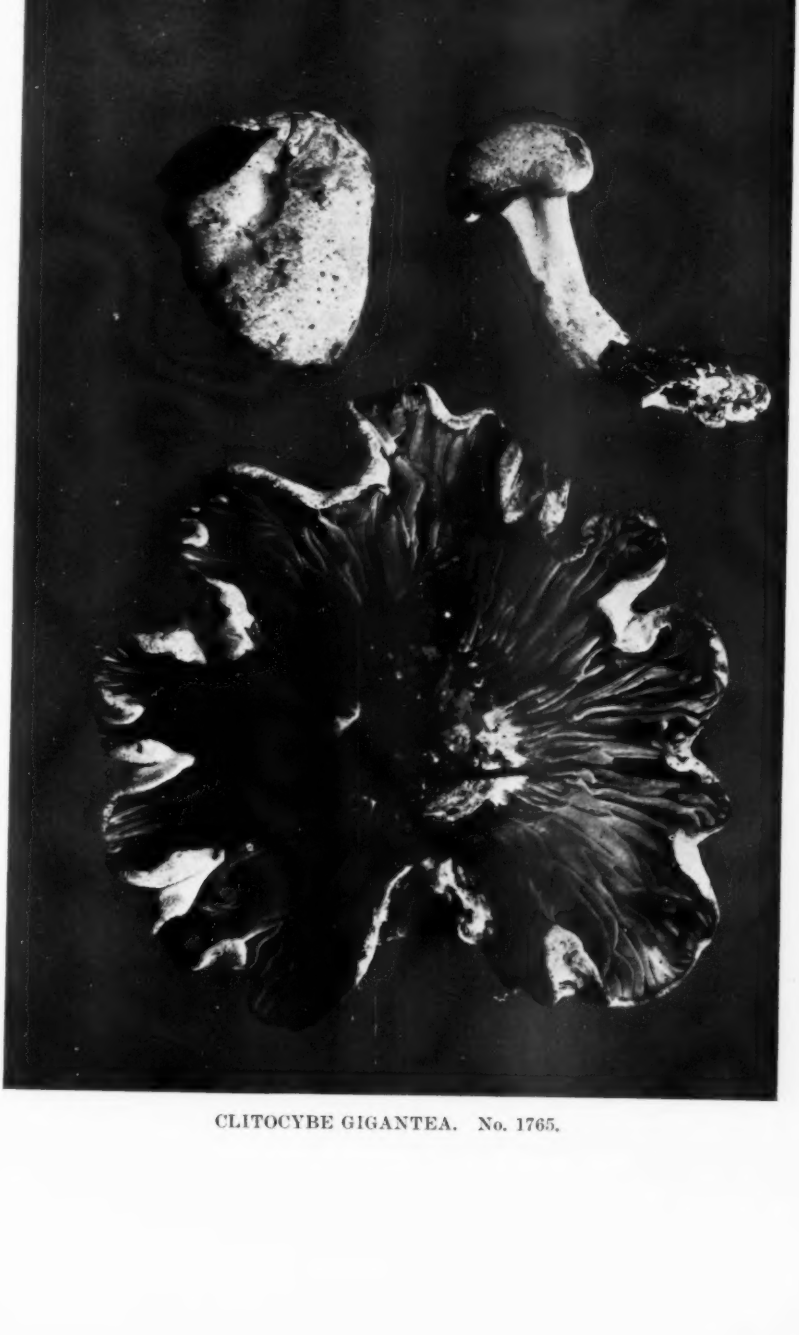
3. **Clitocybe tabescens** (Scop.) Bres.

Pleurotus caespitosus B. & C.
Clitocybe caespitosus (B. & C.) M. A. C. Not *C. caespitosa* Pk.
Clitocybe monadelpha Morg.
Agaricus gymnopodius Bull.

PLATES 12 AND 33

Plants densely cespitose at bases of old stumps, and from underground wood. Cap up to about 7 cm. broad, usually between 4 and 6 cm., expanded and broadly umbonate; tawny or honey color, edge

PLATE 10



CLITOCYBE GIGANTEA. No. 1765.

PLATE 11

CLITOCYBE. No. 3210.

PLATE 12

CLITOCYBE TABESCENS. No. 1342.
Reduced about one-fifth.

often water-soaked and darker, the surface with small scales in center, elsewhere nearly smooth or squamulose-fibrous.

Stem long, dark grayish-brown, tapering to a point at the crowded base, solid, tough, fibrous, bent and usually twisted.

Gills decurrent, not crowded, pale flesh color, often with brown stains.

Spores variable in size in the same plant, white, subspherical to elliptic, smooth, (of No. 1342) 4.8-7.4 x 6.5-10μ.

This plant, which is very common around stumps from July to cold weather, is much like *Armillaria mellea* in habit, color, texture and general appearance, and is easily confused with it in passing. The entire absence of a veil in *Clitocybe tabescens* will, however, serve as an easy distinction between the two plants. Pure cultures of these two species grown on wood, agar and other media by one of our students, Mr. H. R. Totten, Instructor in Botany, shows that *C. tabescens* is certainly distinct from *A. mellea*. In agar, the rhizomorphs of the latter are blackish, while those of the former are white. (Jour. E. Mitchell Sci. Soc. **33**: 96. 1917).

There seems no doubt that Bresadola is right in considering the American plant the same as the European. His good figure is just like our plants (Fung. Trident. **2**: 84, pl. 197. Bulliard's plate, No. 601, is less good). Other synonyms given by Bresadola are *Agaricus socialis* DC., *Agaricus inarmillatus* Schulzer, *Lentinus caespitosus* Berk. Still other names, according to Murrill (N. Am. Flora **9**: 420. 1916), are *Clitocybe aquatica* Banning and Peck and *Armillaria mellea exannulata* Pk. See a note by Lloyd in Myc. Notes **6**: 54. 1901.

While not of first-class quality, this species is edible and on account of its great abundance could probably be made valuable to the housekeeper. It can be easily dried and put away for future use.

For other illustrations see Morgan, Journ. Cinn. Soc. Nat Hist. **6**: pl. 4, 1883; McIlvaine, Am. Fungi, pl. 27 (as *C. monadelpha*), 1900: Hard, Mushrooms, pl. 12 (as *C. monadelpha*), 1908.

182. On underground wood, campus, September 27, 1908.

188, 198, 1342, 1373, 2453, 2457. All around stumps or from underground wood in October. Spores of No. 2457 elliptic, smooth, 5-6.5 x 6-8.5μ, of No. 1373, 4-6 x 5.5-8μ.

Asheville. Not common. Beardslee.

Reported by Curtis (as *C. cespitosus*).

4. **Clitocybe cerussata** Fr.
Clitopilus caespitosus Pk.

PLATE 13

The following is by Beardslee:

Strongly cespitose: cap 3-10 cm. broad, round convex, becoming expanded and plane or depressed, white with a silky luster, often grayish white with a water-soaked appearance with age, margin thin, even or obscurely striate, inrolled at first. Flesh white to watery white.

Gills white becoming dingy or flesh-color, narrow, crowded, many shorter and a few forking, sinuate-adnate to adnate-decurrent.

Stem 7-10 cm. long, usually about 1 cm. thick, spongy stuffed becoming hollow, silky fibrillose.

Spores 2.5-3 x 4-5μ ellipsoid, flesh color in mass.

This is without doubt Peck's *Clitopilus caespitosus*. In many ways, however, it is more suggestive of *Clitocybe* than *Clitopilus*. It is true that the spores have a rosy tint when they are viewed in mass, but they are much lighter than is usual in *Rhodosporae*. In fact if care is not taken to secure a good spore print they may easily pass for white. The fact that a number of species of *Tricholoma, Clitocybe*, and *Pleurotus* have spores that are not pure white lead to the belief that this plant might be known in Europe as a *Clitocybe*. Specimens and photographs were accordingly submitted to Bresadola who positively identified our plant as *C. cerussata* Fr., our usual form being variety *difformis*.

We are therefore referring our plant to this species especially as its large size, fragile flesh and light colored spores seem to indicate a closer relationship with *Clitocybe* than *Clitopilus*.

Asheville. In large masses in the margins of woods. Beardslee.

5. **Clitocybe illudens** Schw.

PLATES 14, 15 AND 33

Cap up to 15 cm. broad, expanded then depressed in center, bright orange or golden yellow; margin elevated or drooping, surface smooth and glabrous. Flesh yellowish, taste and odor rather strong.

Gills close, strongly decurrent, color of cap.

PLATE 13

CLITOCYBE CERUSSATA. Asheville. Photo by B.

CLITOCYBE ILLUDENS.
Near east gate of campus. Reduced.

PLATE 15

CLITOCYBE ILLUDENS. No. 557. Reduced.

Stem long, solid and elastic, bent, tapering downward, color of cap.

Spores (of No. 183) white, sub-globose, smooth, 4-4.6μ thick.

A large and very striking species growing in densely cespitose clusters from the bases of stumps of deciduous trees or from roots near the surface of the ground; not rare in September and October. It was first described by Schweinitz from this State. The entire plant is brightly colored and may be seen from a long distance. It is poisonous to most people though not classed among the deadly species. It is a severe emetic and may also cause intestinal derangement. For cases in detail see Fischer in Kauffman's *Agarics of Michigan*, p. 486. The gills exhibit a marked phosphorescence which may be easily shown by looking at the plants in a dark room.

For other illustrations see White, Bull. Conn. Geol. & Nat. Hist. Surv. 3: pl. 18. 1905; McIlvaine, Am. Fungi, pl. 29a. 1900; Hard, Mushrooms, pl. 10; Mem. N. Y. St. Mus. 4: pl. 68. 1900; Marshall, Mushroom Book, pl. opposite p. 70. 1904.

183. On an oak stump near east gate of campus, September 14, 1910.
184. Near Meeting of the Waters, on a stump, September 30, 1908.
557. By a stump on Cameron Avenue, October 14, 1912.
Blowing Rock. Atkinson.
Asheville. Very common. Beardslee.
Reported by Curtis.

6. **Clitocybe tumulosa** (Kalchbr.) Sacc.

Agaricus multiformis Schaeff., plate 14.

PLATES 16, 17 AND 33

Plants cespitose or gregarious. Cap up to 10 cm. wide, convex, smooth, not viscid, quite irregular, the margin incurved nearly to maturity, remaining bent down, usually strongly lobed and crenated, color grayish-brown or sordid-brown, lighter on the margin, turning nearly black in age. Flesh about 8 mm. thick near stem, very thin on margin, sordid white, tender, tasteless, odorless.

Gills not crowded at stem but much closer at margin, where there are very many short ones, rather narrowly adnate to the stem, not sinuate and varying from *not decurrent* in some plants to distinctly so in others, up to 6 mm. wide in middle, dingy white at maturity and somewhat dingy even when quite young. The gills are very sus-

ceptible to the attacks of insects or snails and are usually almost entirely eaten away before maturity.

Stem up to 6 cm. long, often bent at the base, in our plants usually fused with others into a solid basal mass, sometimes nearly equal above the base, again strongly expanding near the cap; when not fused with others the individual stems are usually decidedly swollen or bulbous below, but base not enlarged in the fused stems except as they expand into the mass; surface smooth, generally with ridges and grooves, almost silky-shining, dull or sordid white; flesh rather fragile, fibrous, solid, but softer-fibrous inside.

Spores white, short elliptic, lateral apiculus at one end, smooth, 4-5.4 x 5.4-6.8μ.

In Chapel Hill this species grows only in ashes, usually where piles of trash have been burned, a fact I have not seen mentioned by others.

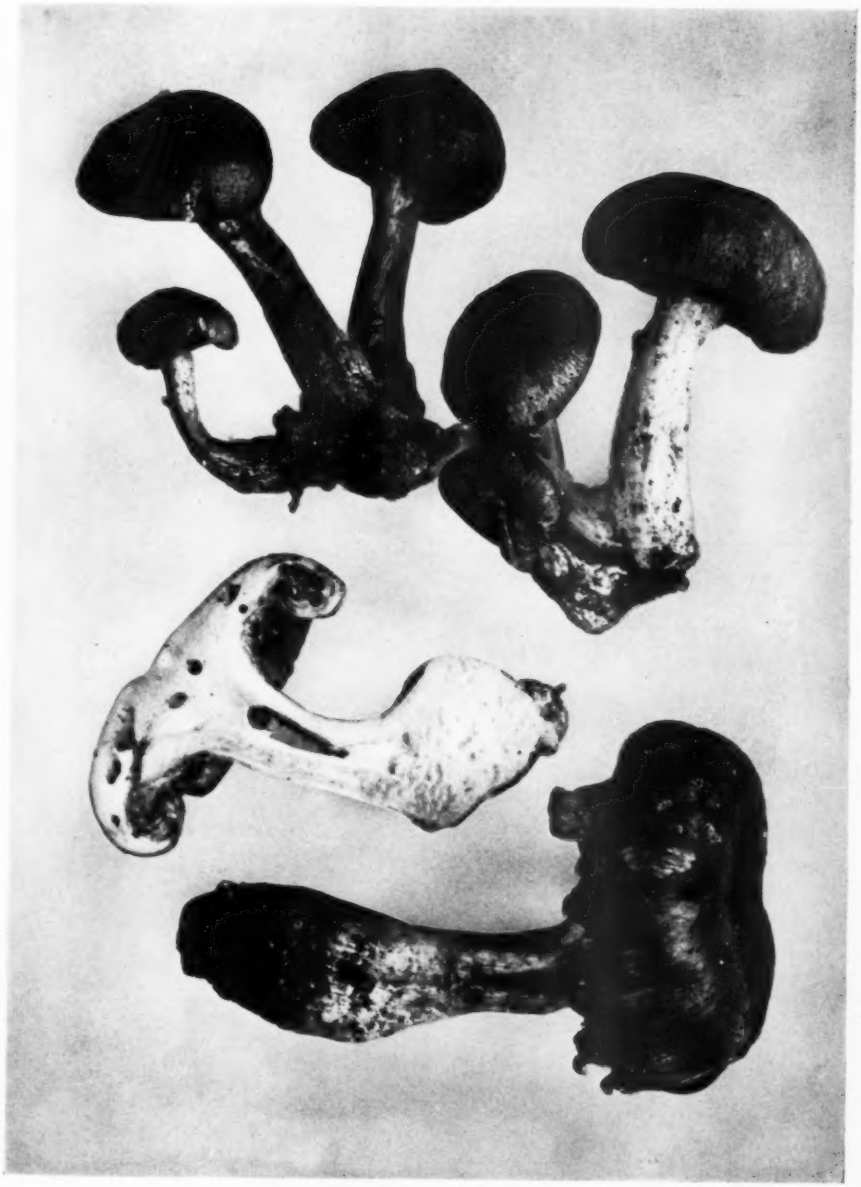
Cooke's illustration of *C. tumulosa* (pl. 105) and Schaeffer's of *A. multiformis* (pl. 14) leave little doubt that their figures represent our plant. This is also true of Bresadola's pl. 32 in Fungi Tridentini, published as *C. conglobata* but later said by him in a letter to Beardslee to represent *C. cinerascens*. *Clitocybe fumosa* Fr. is lighter in color and has a more expanded cap. Peck's *C. multiceps* might well be this, but is described and figured (Bull. N. Y. St. Mus. 139: pl. 117) as being much whiter, and photos by Kauffman (Agaricaceae of Michigan, pl. 157) and Clark and Kantor (Mycologia 3: pl. 52. 1911) show a denser mass of plants. From these interpretations it would seem that *C. multiceps* is nearer *C. conglobata* than *C. tumulosa*, if indeed the two latter are really different. Ricken considers them, as well as *Tricholoma pes-caprae* Fr., the same. Gillet's pl. 689 under the last name is just like our Chapel Hill plant. *Clitocybe multiformis* Pk. does not seem to be different from *C. multiceps* (see Mycologia 7: pl. 164. 1915).

Beardslee agrees that our Chapel Hill plants are *C. tumulosa* and that *C. multiceps* Pk. is the same. He believes that *C. conglobata* is different and we are giving his notes and photographs of this species as he understands it.

1941. In leaves and trash under oaks, October 22, 1915. Spores elliptic, smooth, one oil drop, 5 x 6-7.2μ.

1989. On burnt over ground with *Funaria* moss, oak woods east of athletic field, November 17, 1915.

PLATE 16



CLITOCYBE TUMULOSA. No. 1941.

CLITOCYBE TUMULOSA. Asheville. Photo by B.

2001. In ash pile, south of campus, November 23, 1915.
2006. In ash pile, southwest of campus. Spores 3.7-5 x 5-7.4μ.
2007. In soil containing ashes with moss *Funaria*, woods southwest of athletic field, December 6, 1915. Spores elliptic, smooth, hyaline, 3.6-4 x 5.8-6.7μ.
2008. In soil containing ashes, burnt-over place in woods southwest of athletic field, December 8, 1915.

7. **Clitocybe conglobata** Vitt.

PLATE 18

The following is by Beardslee:

Cap 2-5 cm. broad, at first rounded convex, becoming expanded with the fleshy center somewhat prominent as an obtuse umbo, smoky gray to almost pure white, usually darkest at the center, marked with darker fibrils. Flesh white, thin at the margin, rather fragile; no marked taste or odor.

Gills white, close, moderately narrow, varying in attachment from adnexed to adnate decurrent.

Stem white, solid, curving, furfuraceous at the top, springing in large numbers from a solid, white-fleshed, tuberous mass 10-12 cm. thick.

Spores globose, 6-7μ thick.

This species was found twice at Asheville, and seemed very different from the related species with globose spores, which we have referred to *Clitocybe tumulosa*. Specimens and photos were submitted to Bresadola who referred them as above, with the statement "*C. conglobata* Vitt. Funghi Mangerecci, tab. 34, not Fungi Tridentini, tab. 32, which is *C. cinerascens* Bull."

The first figure will be found to represent our plants well. It shows the cap white to pale gray, and the same densely clustered stems springing from a dense subterranean mass. The figure in Fungi Tridentini does not show these features. We are referring our plants to *C. conglobata* Vitt., therefore, in the sense of Bresadola's later views. As we find it the plant seems amply distinct and well worthy of a specific name.

Asheville. Densely cespitose in thick woods. Beardslee.
Linville Falls. In humus, August 24, 1922. No. 5758. Coker, coll.).

8. **Clitocybe subnigricans** Pk.

PLATES 1, 19, 20 AND 33

Cap 7-11 cm. broad, irregular, the center plane or depressed, margin broadly drooping and more or less zoned by light terraces, much crimped and lobed; surface dry, nearly glabrous in places, but still showing in areas a fine felted tomentum, (under a lens a light, fragmented, inherent pellicle is visible); color a peculiar buffy drab with blackish places where rubbed. Flesh color of cap, tough, elastic, very thin on marginal half, up to 6 mm. thick near stem, odor slight, taste rank and farinaceous.

Gills close, many lengths, not branched, about 6 mm. wide, adnate or mostly decurrent, none sinuate, color of cap, then soon smoky in an irregular way, the distal ends remaining light longest, finally blackish.

Stem 5-7 cm. long, 11-16 mm. thick, nearly equal, tough, solid, surface smoothish to roughish, color of cap at first, then blackish; base deeply inserted in the leaves and without a definite end.

Spores (of No. 3165) white, elliptic, smooth, 4-6.2 x 7.4-10μ.

This interesting plant has been compared with the type and found to agree, both in appearance and spores, which in the type are smooth, elliptic, 4.2-6 x 7-9.5μ.

3165. Deciduous woods by Battle's Branch, October 3, 1918.

3357. In moss bed by path to Meeting of the Waters, June 21, 1919. These two young plants are undoubtedly the same as above. They show that in the young state the cap is covered with a fine squamulose felt. The gills are sinuate and, when young, decurrent by a little tooth. Spores 3.7-4.4 x 6.6-7.7μ.

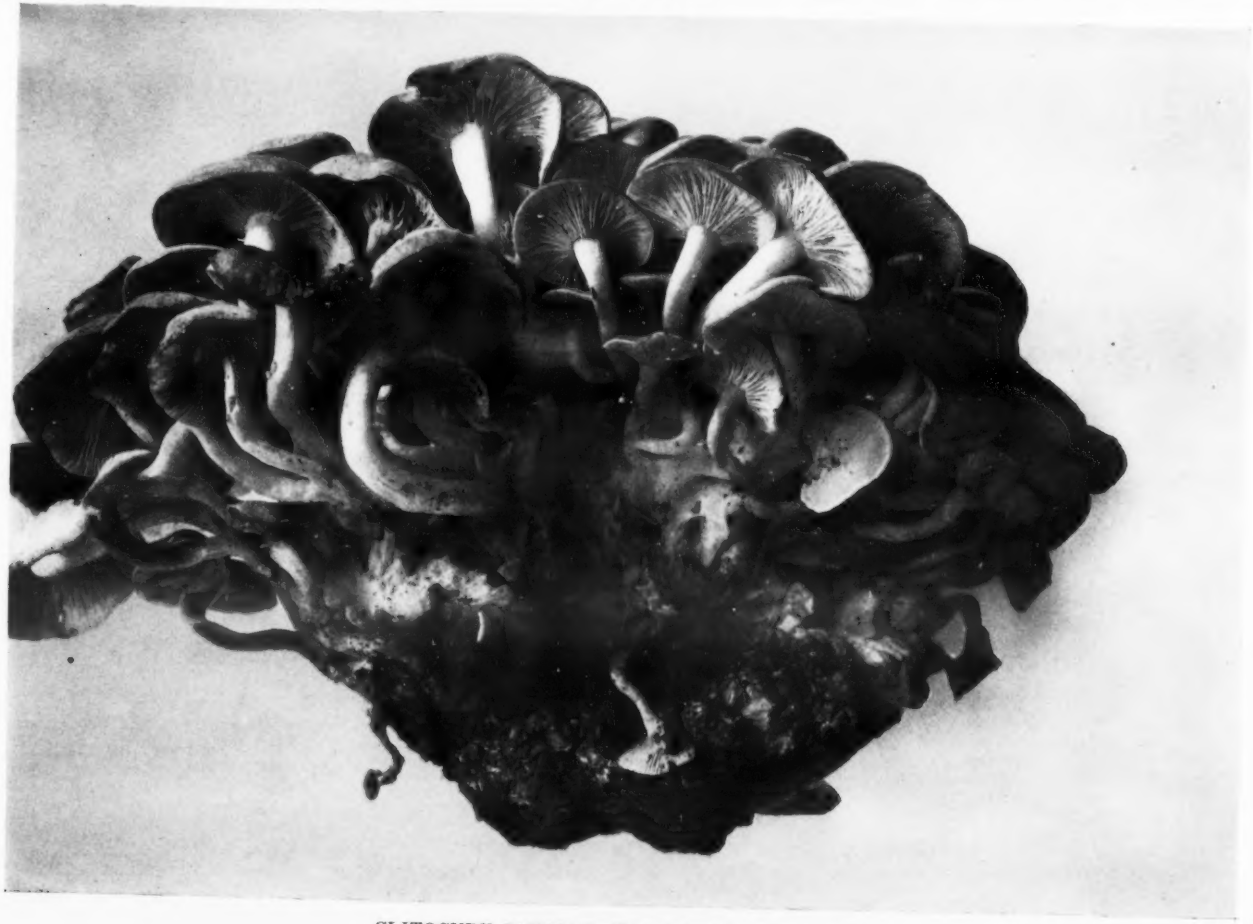
3361. Same place as No. 3357, June 25, 1919. Spores smooth, elliptic, 3-3.7 x 6.2-7.4μ.

3552. Mixed woods by Battle's Branch, October 29, 1919. Gills very crowded.

9. **Clitocybe infundibuliformis** (Schaeff). Fr.

PLATES 1, 21, 22 AND 33

Gregarious or cespitose among leaves in woods or in piles of turf. Cap 4-8.5 cm. broad, soon depressed in center or broadly infundibuliform, usually undulately, lobed and uneven, when young the margin strongly inrolled and distinctly lined by being pressed against

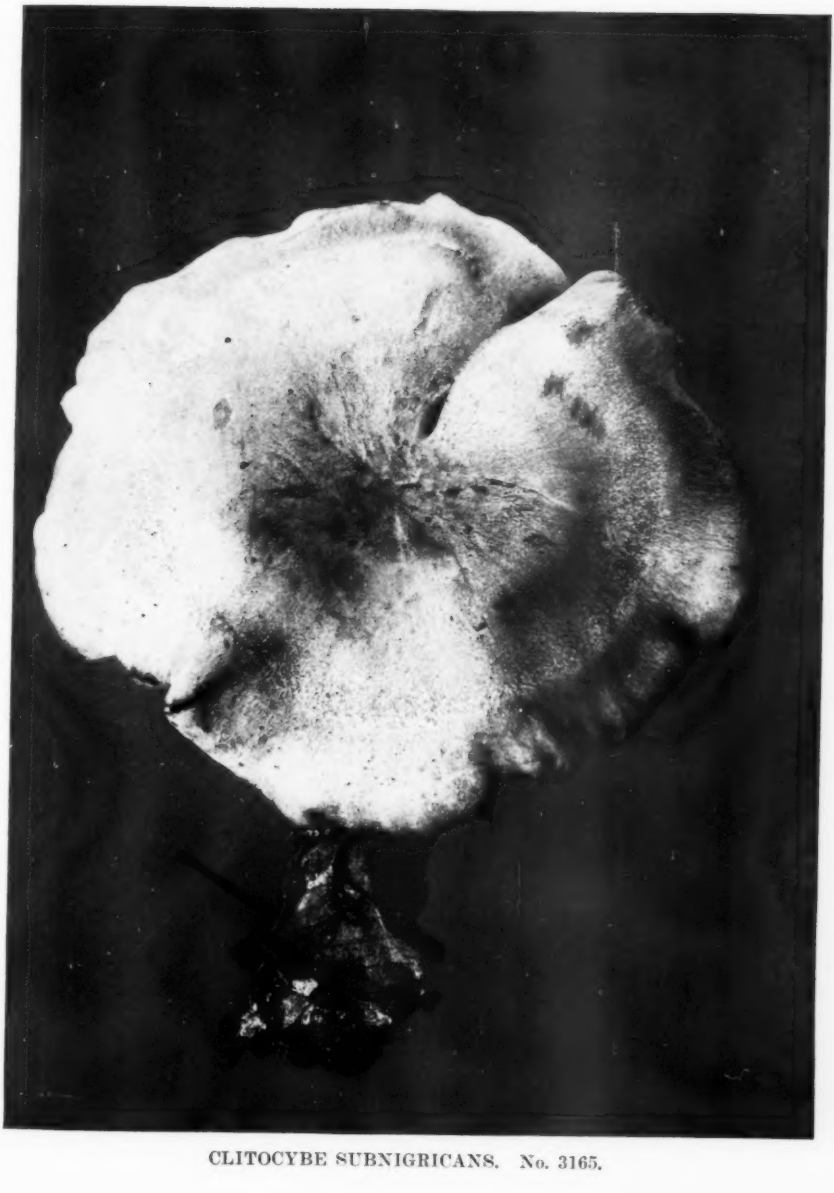


CLITOCYBE CONGLOBATA. Asheville. Photo by B.

PLATE 19

CLITOCYBE SUBNIGRICANS. No. 3165.

PLATE 20



CLITOCYBE SUBNIGRICANS. No. 3165.

the gills just as in *C. odora*, these lines still visible or absent at maturity; surface finely puberulent when young and in protected places until maturity, usually becoming smooth or nearly so from the collapse of the tomentum; color in youth deep reddish tawny, but soon fading to a dull brownish tan, the margin pale and sometimes zoned. Some plants are decidedly flesh color at maturity. Flesh white, soft, 4-10 mm. thick in center, gradually thinning outward, taste fungoid-musty; odor slight, similar.

Gills crowded, slightly decurrent, 2-2.8 mm. wide, some branched, and in No. 2512 abundantly and conspicuously veined in most of the plants (a few with inconspicuous veins); color pale creamy, in drying becoming more like the cap color.

Stem variable in size, 2.5-3.5 cm. long above ground, 5-15 mm. thick, often deeply inserted, nearly equal, color of gills, nearly smooth where exposed, but covered with soft cottony mycelium where protected and bound firmly to the substratum with it, center softly stuffed and often hollowed by grubs.

Spores (of No. 2512) not abundant, smooth, pip-shaped with the small end curved, 2.4-4.5 x 5-7μ.

We are referring this to *C. infundibuliformis* because of its deep reddish color (fading to tan), only slightly tomentose cap, crowded, narrow gills, and spores like those of the European plant. A specimen from Bresadola is just like ours and has spores 3.5-4 x 5.2-7.4μ. Bresadola thinks that *C. adirondackensis* Pk. is the same, and they are certainly very close. A collection of the latter by Peck from Bolton, N. Y., is just like our plants in the dried state and has the same spores (3.5-4.2 x 4.5-7μ). However, there is a milk white plant found at Asheville (Beardslee) and Blowing Rock (Coker) that is very smooth and may conveniently be separated as *C. adirondackensis* (which see).

This species is very near *C. sinopicoides*, from which it may be distinguished only in the most typical forms. In such cases the stouter stem, larger size, more glabrous surface and the vein-like ridges on the margin in youth and often until maturity serve to mark it. The spores are alike, and I have come to the conclusion, after several years of observation, that the two are only different forms of the same species, the larger veined form growing most often under cedars and pines, the smaller with smooth margin under deciduous trees, but not confined to them. The latter often has short, obscure

ridges or a series of dots near the margin which are intermediate between the smooth and veined extremes; smooth plants also occur among the veined ones of cedars. The two forms occur in abundance at the same time and are exactly alike in color, shape, odor, taste, gills and spores.

For illustrations see Dumée, Atlas de Champignons, pl. 16; Cooke, Ills. Brit. Fungi, pl. 107; Gillet, Champ. Fr., pl. 107 (126) and pl. 127; White, Conn. Geol. and Nat. Hist. Surv. Bull. 3: pl. 19. 1905; Hard, Mushrooms, pl. 9, fig. 65; Kauffmann, Agaricaceae of Michigan, pl. 158; Peck, N. Y. St. Mus. Rept. 48: pl. 24, figs. 1-6. 1895; McIlvaine, Am. Fungi, pl. 24, fig. 11.

2512. In a pile of rotting turf by road at cemetery, June 11, 1917.
2767. Same spot as No. 2512, July 24, 1917.
2841. From woods on right of Durham road, October 1, 1917.
3248. In grass lawn of President's house and by sidewalk near, May 28, 1919.
3258. Under cedars in cemetery, May 30, 1919. All these plants except one were distinctly veined on margin. One was quite smooth.
3260. Same spot as No. 2512, May 30, 1919.

Blowing Rock. Atkinson. Coker.
Asheville. Very common. Beardslee.
Reported by Curtis.

10. **Clitocybe sinopicoides** Pk.

PLATES 23 AND 33

Cap up to 5 cm. broad, usually about 3-4.5 cm., depressed in center, or almost plane, sometimes approaching infundibuliform; surface when young minutely pruinose-tomentose, the margin more distinctly tomentose, dry and chestnut red, becoming more or less squamulose and sometimes rivulose when old and fading to ochraceous-buff or even lighter, often with darker dots, margin usually irregular and very wavy, inrolled when quite young. Flesh white, soft, flexible, very thin, about 1 mm. thick half way to margin, much thicker over the stem; taste mild and slightly earthy, not farinaceous.

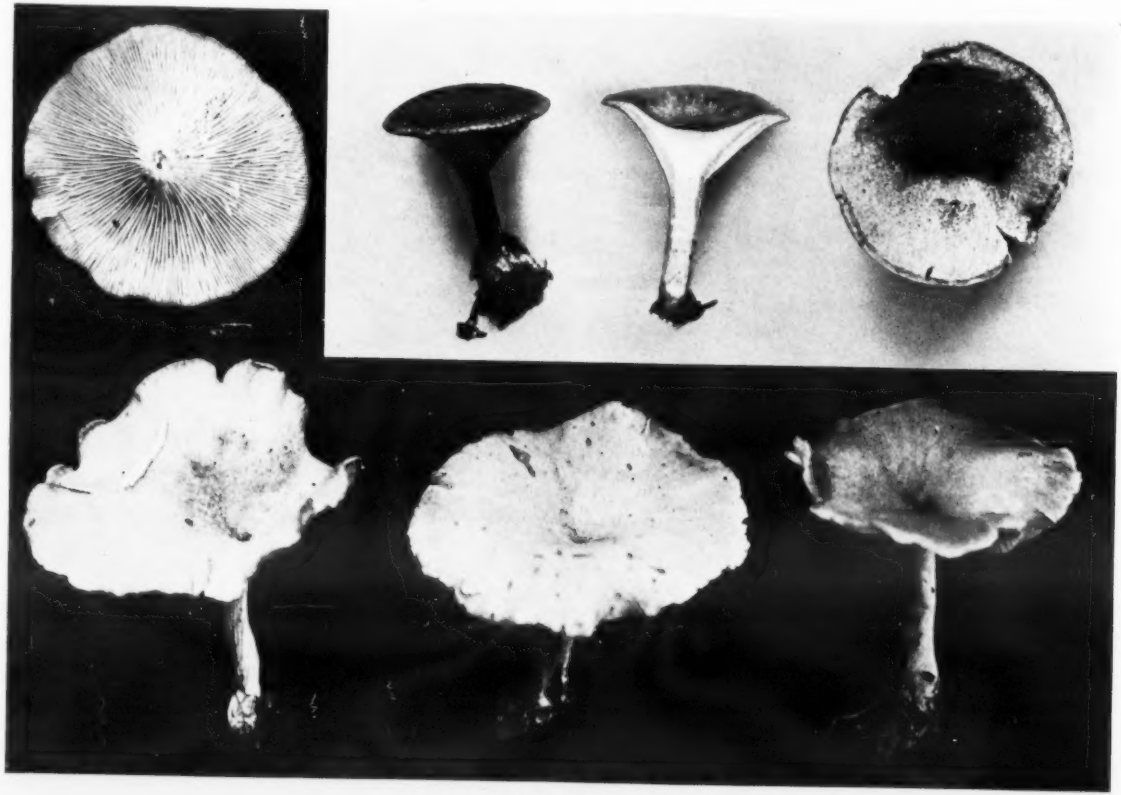
Gills very decurrent, white, changing to creamy and drying when mature to ochraceous buff, close or moderately so, very thin and narrow, only 1.5 mm. wide in center, many short, some forked, in large plants their sides sometimes veined.

Stem color of cap or lighter, smooth, tapering slightly downward, firm at surface and stuffed with soft, dense, white material like the

PLATE 21

CLITOCYBE INFUNDIBULIFORMIS. No. 2512.

CLITOCYBE INFUNDIBULIFORMIS. No. 2512.



CLITOCYBE SINOPICOIDES.
Upper three on right, No. 1140; other four, No. 1414.

cap flesh, tough or rather brittle, about 2-3 cm. long and 2-5 mm. thick, attached firmly to the ground with white mycelium. When mature the entire plant dries to a pretty ochraceous-buff.

Spores white, smooth, pip-shaped, 3.4-4.6 x 4.2-7.4μ.

In humus or grass or on rotten wood, in woods and groves.

We have examined Peck's type of *C. sinopicoides* and cannot distinguish it from our plants. The caps distinctly show the squamulose center and the spores are exactly the same except that a few of the former are a little longer (3.2-3.8 x 7-8.5)μ. In the presence of squamules and cracks on the cap in age the present species is like *C. sinopica*, but a European plant of that species from Bresadola has distinctly larger spores, 3.8-5.5 x 7-9.3μ and differs further in far less crowded gills and smoother cap. This is almost certainly the plant listed by Schweinitz as *C. gilva*, but according to Ricken that species has spherical, spiny spores. The present species is doubtfully distinct from *C. infundibuliformis*, which see for discussion.

614. On a very rotten log, October 24, 1912. Stem eccentric in several of these plants, but not hairy.
1068. In damp grassy place in woods, October 18, 1913. Spores white, oval, smooth, 3.7-4.6 x 5.5-7.4μ.
1140. In clusters, some cespitose, in a shaded lawn, July 16, 1914.
1414. Under pines in burnt over woods, near Piney Prospect, October 24, 1914. Spores 3.4-3.8 x 4.2-5.9μ.
2039. Among shrubs by path west of President's house, June 5, 1916.
2103. Deciduous woods, June 22, 1916.
2273. Oak woods, Lone Pine Hill, June 28, 1916. Spores pip-shaped, 2.4-4 x 5-6μ.
3262. By path on campus, May 29, 1919.
3264. Under oaks in cemetery, May 30, 1919. Margin not marked by lines but some with dots. Spores pip-shaped, 3-4 x 6-7.8μ.

11. **Clitocybe adirondackensis** Pk.

PLATES 24 AND 33

The following is by Beardslee:

Cap 2-7 cm. broad, thin, becoming deeply infundibuliform, dingy white, becoming white when dry, with a narrow marginal zone when moist; flesh thin, white, 2-3 mm. thick.

Gills thin, white, very narrow, scarcely more than 1 mm. thick, forking, long decurrent.

Stem slender 2-4 cm. long, 5-7 mm. thick, stuffed, then hollow.

Spores ellipsoid-ovate, 3-3.5 x 4-5μ.

Asheville. On old leaves; not rare. Beardslee.

Blowing Rock. In leaf mould, Aug. 19, 1922. (No. 5585. Coker, coll.).

12. **Clitocybe clavipes** Fr.

Cap up to 10 cm. wide, plane to depressed in center or cup shaped in age, glabrous, straw drab to buffy drab, hygrophanous. Flesh soft, pure white, 1.5 cm. thick near center; taste slightly acid, odor distinctly fragrant when wilting, rather like jessamine.

Gills close, 4.5 mm. wide, cream color when fresh, a deeper honey yellow when dry, slightly decurrent, edges entire.

Stem 3-5 cm. long, usually 6-10 mm. thick above, smooth, color of cap above; expanded below into a bulb which is up to 3 cm. thick, white and felted with the mycelium which holds the leaves.

Spores white, ovate-elliptic, smooth, with a very distinct oil drop, 3.7-4.2 x 6.5-8.2μ.

Our plants have been compared with *C. clavipes* as understood by Peck (Bolton, N. Y.) and are identical. The spores of the latter are 3-3.8 x 6-8μ. A preference for coniferous woods is noted by Peck, Kauffmann, Gillet and Ricken. Descriptions of these authors do not agree in all particulars, but it seems clear that our plant must be this species. Ricken says that the spores are roughish, but they are certainly not so in the American form.

For illustrations see Peck, Mem. N. Y. St. Mus. No. 4, 3: pl. 46, figs. 1-6. 1900; Gillet, Champ. Fr., pl. 115; Hard, Mushrooms, fig. 69.

Blowing Rock. Under dense white pine growth, Chetola, August 21-22, 1922. (No. 5651 and No. 5677. W. C. Coker, coll.).

13. **Clitocybe media** Pk.

PLATE 33

Cap about 5-8.5 cm. wide, gibbous or nearly plane at maturity, smooth, dull and with appearance of leather, slightly viscid when damp, margin incurved then expanded, often irregular; color brownish-gray all over, between smoke-gray and drab of Ridgway. Flesh white, soft and spongy, gradually thickening toward the stem, tasteless and odorless.

Gills distant to sub-distant, slightly decurrent or adnate, 5-6 mm. wide, ventricose, veined, none branched, pallid and more or less tinted with the cap color.

PLATE 24

CLITOCYBE ADIRONDACKENSIS. Asheville. Photo by B. [above].
CLITOCYBE SETISEDA. No. 1782. [below].

Stem 2.5-5 cm. long, 1-2 cm. thick in center, tapering downward, often flattened, color of the cap or lighter, smooth or pruinose above, flesh solid and like that of the cap.

Spores (of No. 2992) white, smooth, elliptic, 4-5 x 6-7μ, with a large oil drop.

The cap margin is at times marked by darker spots in a row as in *Tricholoma russula*. The species is new to the South, having been reported only from New York and Wisconsin.

For illustrations see Hard, Mushrooms, fig. 64. 1908; Peck, Rept. N. Y. St. Mus. **42**: pl. 1, figs. 9-12. 1889; **48**: pl. 23, figs. 1-7. 1896.

2992. On ground among leaves, Battle's Park, deciduous upland woods, March 19, 1918.

14. **Clitocybe odora** (Bull.) Fr. var. **anisaria** (Pk.) Kauffman.

Agaricus (*Clitocybe*) *anisarius* Pk.

PLATES 25, 26 AND 33

Plants cespitose or solitary in rotting leaves in woods. Cap up to 7.5 cm. broad, convex at first, but soon flat and then plane-depressed or somewhat umbilicate in center, not infundibuliform; margin inrolled when young, then plane or somewhat curved downward; surface dry, roughish with firm inherent squamules which are tipped by fine upright wisps of fibers, the margin covered with short hairy tomentum which is most easily observed in youth. Squamules and tomentum may both become practically invisible after maturity (as in No. 4669). Just back of the margin is also observable in youth a distinct circle of spots which correspond to the little cogs on the stem where the margin touched it. Color light pallid tan or brownish tan or whitish gray at maturity. When young a light bluish olive-tan, the marginal dots deeper smoky-blue-green. The center is darkest at maturity, a smoky drab or dull green, sometimes faded and not much darker than remainder. Flesh white, very brittle, 4 mm. thick near center, gradually thinning to margin. Taste mild, pleasant, like that of *Agaricus campestris*. Odor distinct and exactly like that of sweet fennel or of anise.

Gills crowded, slightly decurrent, and usually a little notched at stem, none branched, numerous short ones of any length, scarcely 2 mm. wide, color nearly white, then light tan, margin usually eroded in marginal half and nearly even near the stem.

Stem 4-5 cm. long, up to 5 mm. thick, nearly even below, coated with and fading into the thick white mycelium. Color of cap, when young nearly white. At top finely granulose and usually with a little collar of cogs about 1 mm. below the tip, middle region faintly fibrous, basal coated with white mycelium. Texture fibrous, rather brittle, inside stuffed, sometimes partially hollow in age.

Spores (on No. 1881) decidedly cream in bulk, elliptic, smooth, 4.5-5 x 5-7.2μ.

Our plants differ from the typical *C. odora* in the roughish-squamulose cap, quite close gills, hairy margin marked with dots. The loss of greenish color at maturity may also occur in the typical form. Peck's description of his *C. anisaria* (N. Y. St. Mus. Rep. **32**: 26. 1879) is much more like our form, with narrow, crowded gills and the cap "adorned with minute, innate fibrils, slightly pruinose and substriate on the margin." In some of our collections this squamulose tendency is carried much further than this, the cap being furnished with rough, raised lines which meet in pairs and end in a free upright wisp. These wisps may disappear in age. The margin, too, is distinctly short-hairy, with hairs arranged in two or three more or less distinct concentric lines about 1 mm. apart. We find the spores of Peck's type to be 4.2-5.5 x 7.4-8μ.

For illustrations see Murrill in Mycologia **7**: pl. 166. 1915 (as *C. virens*. This shows a rough cap); McIlvaine, Am. Fungi, pl. 24, fig. 9; Marshall, Mushroom Book, pl. 15 (as *C. virens*); White, Conn. Geol. and Nat. Hist. Surv. Bull. **3**: pl. 17. 1905. For the European form of *C. odora* see Gillet, Champ. Fr., pl. 113 (85, 134); Sowerby, Engl. Fungi, pl. 42; and Bulliard, Herb. Fr., pl. 556, fig. 3; Patouillard, Tab. Fung., No. 404. 1886.

457. On dead bark and leaves near Battle's Branch, September 28, 1912. Spores light creamy ochraceous, 4.9 x 7.4μ.

1881. Among decaying oak leaves, Lone Pine Hill, October 3, 1915.

1883. Under pines and cedars south of the iron mine, October 3, 1915.

3562. Mixed woods west of Pittsboro Road, October 31, 1919. Odor distinct, margin ridged, olive colors in youth.

4669. Mixed woods by Fern Walk, October 3, 1920. Spores pale buff, smooth, elliptic, with one large, distinct oil drop, 3.7-5 x 5-7.4μ.

4896. On bank of Battle's Branch, October 5, 1921.

Reported by Schweinitz as *C. odora*.

PLATE 25

CLITOCYBE ODORA VAR. ANISARIA. No. 3562.

CLITOCYBE ODORA VAR. ANISARIA. No. 1881.

15. **Clitocybe ectypoides** Pk.

PLATES 27, 28 AND 33

Very persistent and slow to decay. Cap up to 9.8 cm. wide, usually 2-3 cm., hygrophanous, deeply umbilicate, the margin inrolled, or at maturity reflexed, often with a sinus on one side, and frequently splitting in age into several parts; surface distinctly lined radially with fibrous streaks; when young, distinctly but sparsely squamulose, especially toward the margin, with small tufts of darker fibers which terminate the fibrous lines; color when water-soaked dull ochraceous with a superficial tint of purplish-red; when not soaked the purple-red color is much more distinct and as it is confined mostly to the fibers and squamules it is much plainer on the margin. In old age this superficial tint becomes almost or quite invisible to the naked eye, but with a lens can be detected at all times on the margin. Flesh quite thin, 1.5 mm. thick near stem, ½ mm. thick near margin, whitish, tough, nearly tasteless.

Gills rather close to sub-distant, not venose-connected, some forking and occasionally anastomosing, narrow, only about 2 mm. wide at best, the edges blunt; color nearly the same at all ages, a clear golden yellow (about mustard yellow of Ridgway). On account of the shape of the cap the gills are apparently decurrent, but in section it will be seen that they are not at all so, but end at a slight ridge at the top of the stem.

Stem up to 2.5 cm. long and 4.5 mm. thick, equal, quite firm and tough, solid at all ages, surface smoothish, faintly lined longitudinally, pale, soaked-ochraceous, very light when dry, lighter than cap at all times, *never yellow*. The tip is nearly white and the base enlarged by the soft white, compacted mycelium.

Spores (of No. 1421), white, ovate, very hyaline, at first sight only the bright oil drop visible. 3.8-4.2 x 5.9-8.5μ.

On rotting pine logs, not common.

Others have failed to mention the reddish-purple color of the cap fibers, but as in all other respects our plant is unmistakably *C. ectypoides*, a clearly marked species, I have no doubt that this character has been overlooked. The species has the size and somewhat the appearance of *Omphalia strombodes* but easily differs in the purplish red tint to the cap, the solid stem, and in the gills being

only apparent decurrent. The present species should be compared with *Omphalia xanthophylla* B. & C. which is represented in the Curtis Herbarium by two plants from S. C. (Ravenel). I could get no good spores from them.

1421. On rotting wood by Bowlin's Creek, October 26, 1914.
1774. On a very rotten pine log half way down Lone Pine Hill, September 14, 1915.
3781. On pine logs in woods, November 20, 1919. Largest cap 9.8 cm. broad. Gills golden, cap squamulose.

Asheville. On old logs, usually cespitose. Beardslee.

16. **Clitocybe cyathiformis** (Bull.) Fr.

PLATES 1, 29 AND 33

Cap 2-5.5 cm. broad, convex on margin, the center broadly umbilicate; smooth, not viscid, strongly hygrophanous, not striate, deep brown, sayal brown of Ridgway when not water-logged, the margin becoming a darker coffee color. Flesh paler, thin (1.5 mm.), elastic, fibrous and toughish; odor and taste strongly farinaceous.

Gills close, decurrent, arcuate, 5 mm. broad, margin even, venose connected, color of cap, with a faint or distant lavender tint and a pale sheen.

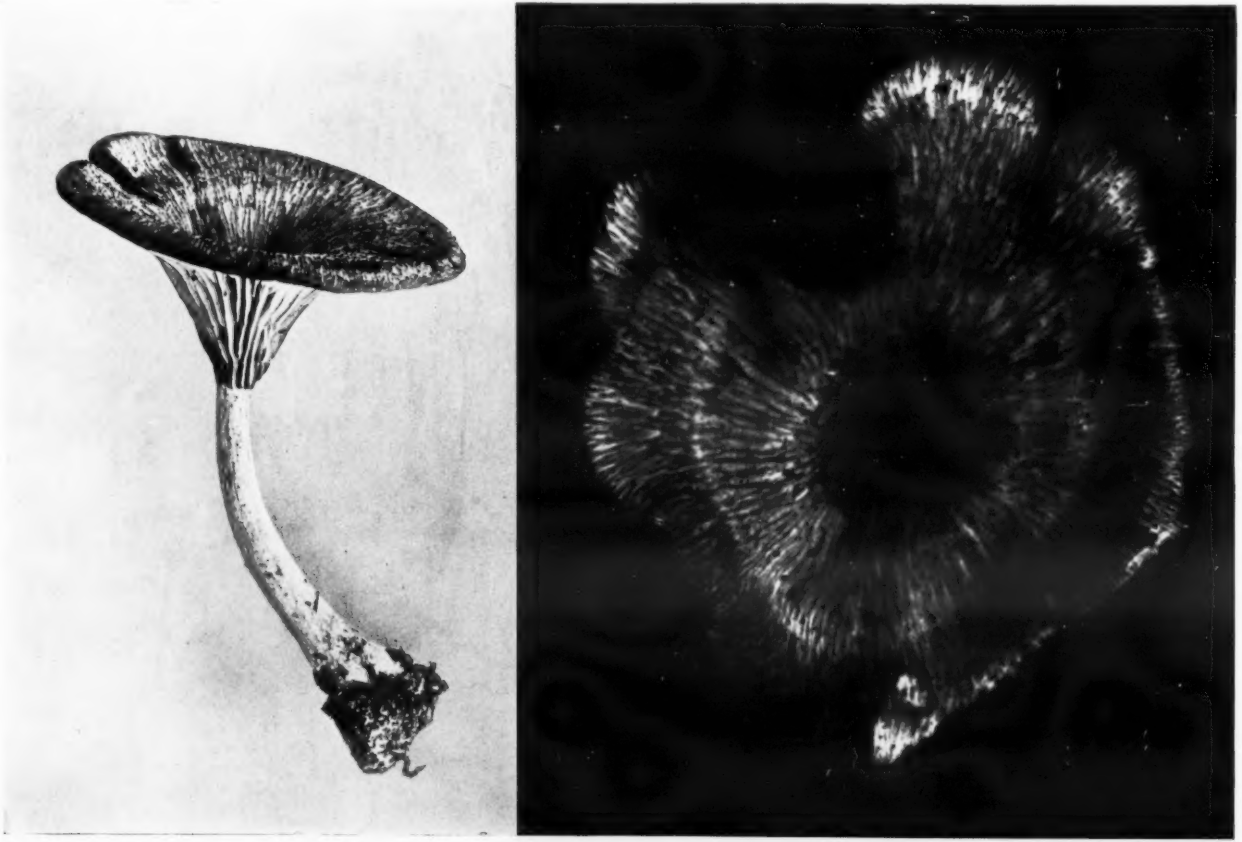
Stem long, up to 9 cm., enlarged downward, flattened or irregular, about 5-8 mm. thick above, color of cap above but white below with mycelium and with white silky lines from superficial fibers except at the minutely pulverulent tip; texture tough and fibrous, stuffed with white fibers, dark near surface.

Spores (of No. 4934) faintly pinkish-lavender on a heavy print, smooth, elliptic, very granular when first shed but soon showing a very large oil drop, 4.2-6.2 x 9-12.2μ. Basidia 5.5-7.4μ thick, clavate, 4-spored. Hymenium 40-45μ thick. Context of gills rather close, the threads about 4.5-5.5μ thick. Scattered rather sparsely among the normal basidia are cells of the same size and shape, but peculiar in having two longer and unequal projections without spores; the longer projections about 14μ long, the shorter about 11μ. If abnormal basidia, their regularity is remarkable.

Very rare in Chapel Hill and apparently occurring only in late fall or winter. According to Ricken it appears in Germany only after frost.

CLITOCYBE ECTYPOIDES. No. 1774.

PLATE 28



CLITOCYBE ECTYPOIDES. Asheville. Photo by B. [left]; No. 3781 [right].

Our plants look very much like Bulliard's pl. 575, fig. M, and like Sowerby's pl. 363. Hussey's pl. 1, Vol. 2, has the gills much lighter than in ours. All have the caps more deeply and broadly depressed. Gillet's pl. 116 (94) is entirely too pale, as are the gills in Cooke's pl. 113 (166). Ricken's pl. 104, fig. 1, has the right color of cap, but is striate. For microscopic detail as well as a drawing in color see Hoffman, Icones Analyt. Fung., pl. 3. 1861; see also Kauffman, Agaricaceae of Michigan, pl. 159. Peck's *C. subconcava* should be compared (the spores as given by Peck are smaller.) Murrill thinks the *Agaricus cyathiformis* of Fries and of Bulliard are different and that *C. poculum* Pk. is the same as Fries's species. Our plants seem to be the darkest form of the species, particularly as regards the gills. The species is very variable, particularly as regards color. The spores agree well with the dimensions given by Kauffman and by Ricken. The only serious difficulty is the very distinct farinaceous taste which is not mentioned by others. This taste and the lavender spores suggest *Clitopilus,* but the color would escape anyone except in a heavy print. The spore color is very faint, but was noticed by five out of six observers who saw the print.

4934. In decaying leaves of mixed woods under honey-suckle vines on damp ground, December 7 and 11, 1921.

Asheville. Very common. Beardslee.
Reported by Schweinitz.

17. **Clitocybe pinophila** Pk.

PLATES 30 AND 33

Cap hygrophanous, 1.3-4.2 cm. broad, plane in center or slightly depressed or umbilicate, margin curved or nearly plane, not striate, smooth, a drab tan or buffy tan or pale whitish tan, darker when wet. Flesh thin, pliable, of pleasant taste (not farinaceous); odor none.

Gills rather close, slightly and unequally decurrent, nearly white then buffy tan, about 1.5-2.5 mm. wide.

Stem 2-3 cm. long, thick above (up to 7 mm.), tapering downward, color of cap and mealy at top, darker brown and nearly smooth downward, the very base whitened with mycelium, stuffed then hollow, toughish.

Spores (of No. 2969) elliptic, smooth, 2.5-3 x 5-7μ.

Our plants agree well enough with Peck's description and like the northern form they are confined to pine woods. The absence of a farinaceous taste is not a serious discrepancy. Peck gives the spores as nearly elliptical, 5-6.4μ long, which agrees quite well, but an authentic specimen from his herbarium (Catskill Mtns., Peck, Coll., not type, which we could not find) has spores somewhat shorter than in our plants, 2.2-3 x 3.4-4.5μ (possibly not fully mature). Kauffman's Michigan plants have spores 4 x 5-6μ, which is distinctly broader than in our southern form. The European *C. phyllophila* and *C. pithyophila*, which are quite near, are supposed to be larger and whiter. Ricken gives the spores of the former (he considers the latter a pine-loving form) as 3-4 x 4-5μ. Spores of a plant of *C. phyllophila* from Bresadola are 2.5-3.7 x 4.2-5.4μ. Schweinitz's record of *C. phyllophila* is probably based on the present species. For the white plant known as *C. pithyophila* in America see the photo by Hard, in his Mushrooms book, fig. 73, p. 100.

Beardslee finds at Asheville, on pine needles, a whiter plant that would easily pass for *C. pithyophila*, but as it has all other characters, including the spores, the same as the present species we cannot believe it specifically distinct. Beardslee's description of this whiter plant is as follows:

Cap 2-6 cm. broad, watery white when moist, becoming pure white when not soaked, glabrous, thin, plane, but a little depressed at the center, often with the margin waved or lobed. Gills white, crowded, narrow, decurrent. Stem white, stuffed, then hollow, somewhat compressed. Spores ellipsoid, 6-7 x 3-4μ.

2964. On ground, pine woods, Strowd's pasture, December 13, 1917. Spores 2.2 x 4.8-5.5μ.

2969. On ground under pines and persimmon trees, Strowd's pasture, December 6, 1917.

2957. On ground, pine woods, Strowd's pasture, December 3, 1917. A form. Spores 2.2-3 x 5.2-7μ.

Asheville. Occasional. Beardslee.

18. **Clitocybe setiseda** (Schw.) Sacc.

Clitocybe eccentrica Pk.

PLATES 24 AND 33

Cap up to 3 (rarely 6) cm. wide, deeply umbilicate, surface very

PLATE 29

CLITOCYBE CYATHIFORMIS. No. 4934.

PLATE 30

CLITOCYBE PINOPHILA. No. 2969.

minutely squamulose, scarcely more than pruinose (not noticeable except under a lens), not at all striate or fibrous, a very faint pinkish tan or soiled white. Flesh very thin, less than 0.5 mm. in marginal half, color of cap, quite strong and tough, decidedly bitter.

Gills very much crowded, thin and narrow, only 1.5 mm. wide in middle, pointed at both ends, many short, none branched, margin quite entire, decurrent, color of cap at certain angles, faintly cream colored at others.

Stem about 2 cm. long to gill tips, 1.5-2.5 mm. thick near top, somewhat larger downward, color of cap, smooth or minutely scaly-dotted like the cap except below where is is covered with long, tough, creamy hairs and strands which penetrate far into the surrounding trash; texture of stem very firm, tough and strong, with a softer central core which may become partly hollow.

Spores (of No. 817a) white, smooth, very small, oval-elliptic, about 2.7-3 x 3.8-4.2μ.

Schweinitz's plant has not been recognized since he described it from this state in 1822. It was placed by him under the subgenus *Omphalia*, but Curtis and Saccardo place it in *Clitocybe*. The description agrees so well with our plants that I see no reason why this name should not be applied to them. *Clitocybe eccentrica* is the same. A plant from Peck's herbarium, not type but authentic (Ray Brook, N. Y., Peck, coll.), is exactly like ours and has the same spores except slightly longer (2.8-3 x 4-5μ). From published data it seems impossible to separate this from *C. candicans*. Kauffman's spore measurements for the latter would serve to distinguish (4 x 5.5-6μ), but Ricken's measurements are like ours (2-3 x 4-5μ). *Omphalia scyphoides* Fr. is also hard to separate.

In most species of this group the cap has a tendency to become one-sided at times, thus appearing eccentric. Following is a translation of the original description (Schr. Nat. Ges. Leipzig 1: 88. 1822):

"White, becoming yellowish, small, cap thin, infundibuliform; gills crowded, thin, decurrent; stem with white, radiating hairs. Rare in autumn among leaves. Stem attached to leaves, hairs about one inch long, spreading in a stellate manner."

817a. On rotting bark, twigs, and leaves, woods southeast of campus, November 7, 1911.

1782. On a very rotten mossy log, Lone Pine Hill, September 14, 1915. Reported by Schweinitz.

19. **Clitocybe dealbata** Sow.

C. sudorifica Pk., toxic form.
C. morbifera Pk., toxic form.

PLATES 31 AND 33

Small plants growing gregariously in grass in lawns and pastures, not rarely cespitose in twos. Cap up to 4.5 cm. in diameter, usually smaller, smooth or sometimes slightly pruinose, especially near the margin, dull or shiny, wavy and often irregular, depressed in center (umbilicate); color a light buff or fleshy buff, sometimes with brown areas; the thin margin incurved and whitish, and slightly extended beyond the gills. Flesh very thin towards the margin, thick towards the center, about 2.5 mm. thick half way between; pale flesh color, with a distinct taste of meal, not at all bitter. The taste is just like that of *Tricholoma panaeolum* except that it is not bitter. As the plants get old they often become water-soaked and therefore much darker brown.

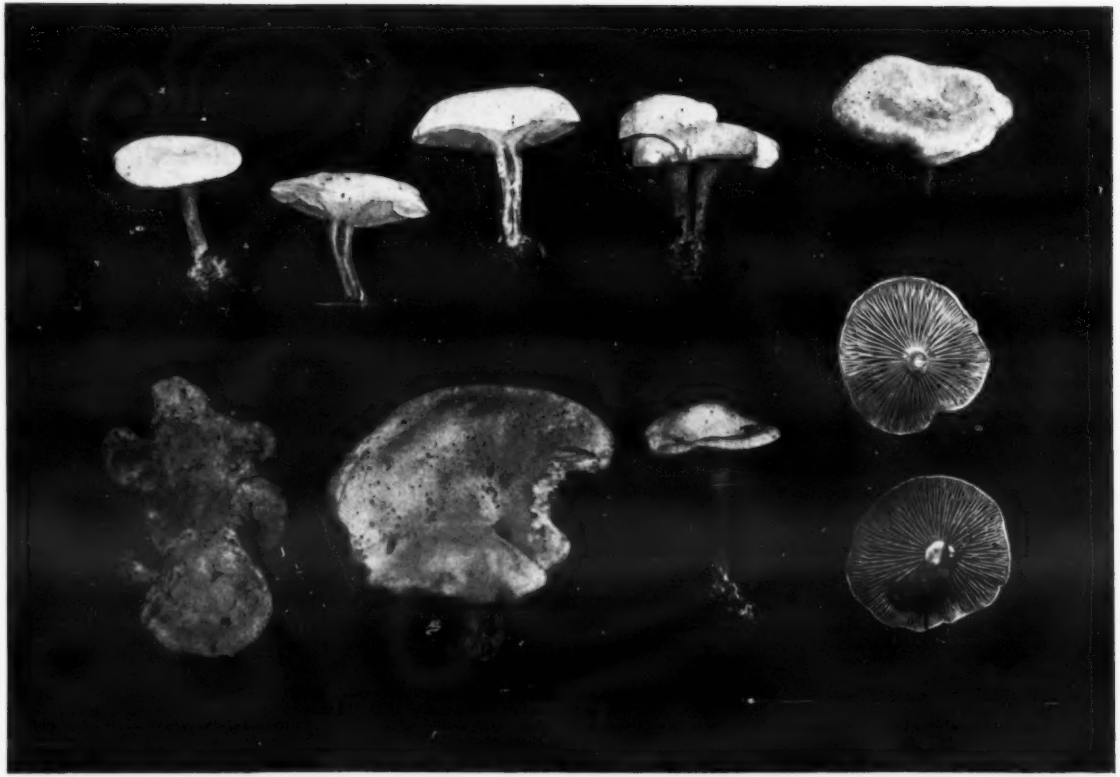
Gills moderately close, deepest in middle where they are 3.5-5 mm. deep, not branching, slightly notched at the stem, not decurrent, fleshy white, then fleshy tan.

Stem color of cap, 1.5-2.5 cm. long, about 3 mm. thick in center, tough and elastic, solid or hollow, smooth, pruinose at top and bottom, slightly tapering towards the base, white at base, and the white mycelium often obvious.

Spores (of No. 929) white, very small, smooth, elliptic, 2-2.5 x 3.8-5.2μ.

The color of our plants is not pure white as is described for the species. From the farinaceous taste and odor this would be var. *minor* Cooke, but that is said to grow in leaves. It is almost exactly like the form that grows in mushroom beds and described as var. *deformata* by Peck.

Two toxic forms have been described by Peck, *C. dealbata sudorifica* (N. Y. St. Mus. Bull. **150**: 43. 1911. Later described as a species in Bull. **157**: 67, pl. 7, figs. 1-6. 1912) and *C. morbifera* (Bull. Torr. Bot. Club **25**: 321. 1898). These do not seem to be distinguishable morphologically in Murrill's opinion (Mycologia **7**: 260. 1915), although Kauffman treats them as distinct. We have examined the types of both and find them alike and like our plants, and the spores are the same in all three cases (*C. sudorifica*, 2.2-3 x 4-5.2μ; *C. morbifera*,



CLITOCYBE DEALBATA. No. 929.

PLATE 32

CLITOCYBE RIVULOSA. No. 907.

2.5-3 x 3.7-4.8μ). For the toxic effects of these two forms see the original descriptions. Peck considers the latter as more serious in its effects than the former, which, in the cases reported by him, caused only a profuse perspiration in man, but the death of rabbits and guinea pigs; later, however, Roberts (Mycologia 13: 42. 1921) found its effects to be somewhat more serious, causing profuse perspiration,. interference with vision, diarrhoea and other unpleasant symptoms.

For good illustrations see Peck (l. c., as *C. sudorifica*); Sowerby, Engl. Fungi, pl. 123, 1798; Cooke, Ills. Brit. Fungi, pl. 104 (142) (larger than American plant), pl. 173 (as var. *minor*, like American form); Gillet, Champ. Fr., pl. 117.

929. Gregarious in grass in northwest side of Arboretum, October 18, 1913. There is another group of these plants in the northeast side of the Arboretum, near the smallest live oak tree. Both of these groups appear every fall.

977. In hillside pasture, west side of Glen Burnie Farm, November 11, 1913.

1466. Pasture, east side of Glen Burnie Farm, November 2, 1914.

Asheville. Common, often in lawns under trees. Beardslee.

20. **Clitocybe rivulosa** (Pers.) Fr.

PLATES 32 AND 33

Cap up to 5.5 cm. wide, usually 3.5-4 cm., irregularly lobed, elevated and depressed; covered with a thin, whitish or light tan superficial layer that is marked by many rivulose lines and collapsed areas that show the cartilage colored flesh below; margin inturned always, milk-white when young. Flesh barely mealy in taste, not bitter, cartilage color, rather brittle, only about 2 mm. thick.

Gills light fleshy-cartilage color, somewhat crowded, not decurrent, about 3 mm. wide in center.

Stem only 1-1.5 cm. long, about 4.5-5 mm. thick, color and surface just like the cap; firm and solid.

Spores (of No. 907) white, smooth, elliptic, very small, 2.6 x 4.2μ.

The characters are well shown in photo of No. 907. The rivulose markings of the cap are remarkably like those of *Clitopilus novaboracensis*.

Rare, and heretofore reported in the United States only from

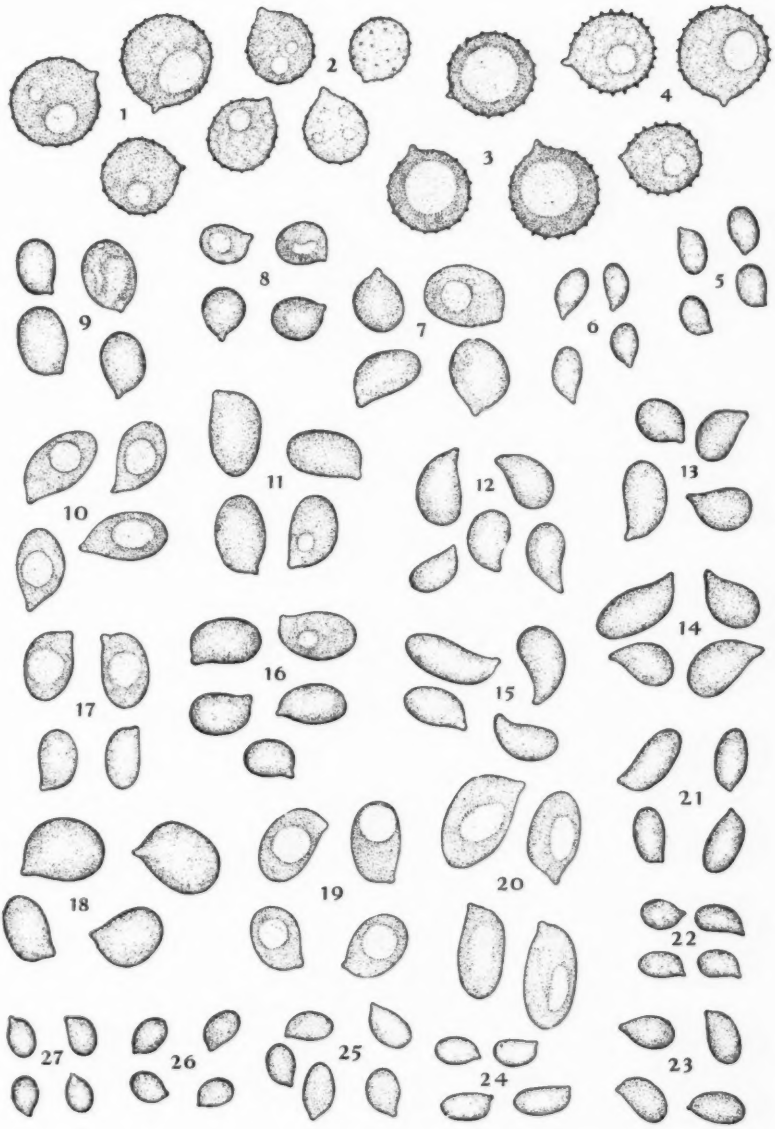
New York. In Chapel Hill they are known only in one place, where they occur gregariously every fall in rainy weather. They have been observed for three years, and are remarkably constant. This is apparently only another of the numerous forms of *C. dealbata*, which is indistinguishable except for the absence of rivulations. A plant of *C. rivulosa* from Bresadola is like ours and has the same spores (2.5-3.2 x 4-5μ) which are like those of *C. dealbata*.

907. Nine plants on edge of sidewalk west of Mrs. Kluttz's, October 11, 1913.
1269. From the same spot as No. 907, and like them in every way, September 26, 1914. Spores 2.5-3 x 4-4.8μ.

EXPLANATION OF PLATE 33

Laccaria ochropurpurea. No. 4675, fig. 1.
Laccaria laccata. No. 2960, fig. 2.
Laccaria amethystea. No. 5119, fig. 3.
Laccaria tortilis. No. 3344, fig. 4.
Clitocybe candida. No. 3546, fig. 5.
Clitocybe sp. No. 3210, fig. 6.
Clitocybe tabescens. No. 1373, fig. 7.
Clitocybe illudens. No. 183, fig. 8.
Clitocybe tumulosa. No. 2006, fig. 9.
Clitocybe subnigricans. No. 3165, fig. 10; type, fig. 11.
Clitocybe infundibuliformis. No. 2512, fig. 12.
Clitocybe adirondackensis, Bolton, N. Y., fig. 13.
Clitocybe sinopicoides. No. 3264, fig 14; type, fig. 15.
Clitocybe media. No. 2992, fig. 16.
Clitocybe odora var. anisaria. No. 4669, fig. 17.
Clitocybe anisarius. Type, fig. 18.
Clitocybe ectypoides. No. 1421, fig. 19.
Clitocybe cyathiformis. No. 4934, fig. 20.
Clitocybe pinophila. No. 2969, fig. 21.
Clitocybe setiseda. No. 817a, fig. 22.
Clitocybe eccentrica. Ray Brook, N. Y., fig. 23.
Clitocybe dealbata. No. 929, fig. 24.
Clitocybe sudorifica. Type, fig. 25.
Clitocybe morbifera. Type, fig. 26.
Clitocybe rivulosa. No. 1269, fig. 27.
All figures x 1620.

PLATE 33



THE FRUITING STAGE OF THE TUCKAHOE, PACHYMA COCOS

PLATES 34-37

By FREDERICK A. WOLF

The names tuckahoe, Indian bread or Indian potato appear to be quite generally known in the Coastal Plains section of the Carolinas as a designation for certain tuber-like structures which grow under ground. These structures are frequently unearthed by the plow especially when timbered lands are brought under cultivation. During the past spring, fifteen specimens were collected near Raleigh, N. C., in a situation where the land had been cleared and broken in preparation for a tobacco plant bed. Subsequently four other specimens were unearthed by the writer and several of his colleagues in the same locality.

My acquaintance with tuckahoe extends over a period of several years since occasional specimens, similar in appearance and accompanied by inquiries as to their nature, have been received at the botanical laboratories of this Station. An examination showed that a tuckahoe is obviously the sclerotial or resting stage of some fungus and as such is composed of a vegetative mass of fungous tissue. This fact gave no clue to the identity and systematic position of the fungus since various fungi are known to produce sclerotia. An examination of published reports on large sclerotia furthermore showed that not only the affinities of the tuckahoe, *Pachyma Cocos*, which has been collected by a number of botanists, but also the origin and formation of these subterranean fungous masses have remained for years an unsolved botanical problem. It was the writer's good fortune, however, during May, 1922, to observe the fruiting stage of this fungus. The present purpose is, therefore, to assemble the information in hand as a contribution to our knowledge of this unusually interesting form.

HISTORICAL

The name tuckahoe is of Indian origin and is apparently generic among them for all round or roundish edible roots. Gore (7) quotes the statement of Trumbull, an ethnologist, that the word is derived

from ptuequi or ptuckquen which signifies that which is made round or rounded as a loaf or cake. The name, varied by the dialects of the several tribes, applied to all esculent bulbous roots. These statements are confirmed by such historians as Smith (16), Beverley (3), Campbell, (4) and Kalm (9), who record such tribal names as tawkee, petukqui, pittikwow, 'tuquauh, petukuineg, puttuckqunnege, tockawhoughe, tawko, tuckah, and tawkin. Campbell says, "The tockawhoughe was in summer the principal article of diet among the natives. It grows in the marshes like a flag and resembles somewhat a potato in size and flavor. Raw, it is no better than poison so that the Indians are accustomed to roast it and eat it mixed with sorrel and corn meal. There is another root found in Virginia called tuckahoe and confounded with the flag-like root described above and erroneously supposed by many to grow without stem or leaf. It appears to be of the convolvulvus species[1] and is entirely unlike the root eaten by the Jamestown settlers." No less an authority than the Swedish botanist Kalm, whose travels in America shortly before the Revolutionary War are recounted in two volumes published in 1772, states that the word tawko referred to the Virginia wake robin, *Arum virginicum*, and tawkee to golden club, *Orontium aquaticum*. While the Indians no doubt included under the name tuckahoe the tubers and roots of a number of flowering plants as well as *Pachyma Cocos*, botanists have come to apply this designation exclusively to tuberous fungous masses.

The first botanical description of this tuckahoe was made by Clayton (5) in 1762 in his Flora Virginica, published by Grovinius. He was under the impression that the plant was one of the puffballs and accordingly sent specimens to Grovinius under the name *Lycoperdon solidum*. Next it is supposed by some to have been described by Walter (18) in 1788 in his Flora Caroliniana under the name *Lycoperdon cervinum*. Later, it was well described by Schweinitz (15) in 1822 as *Sclerotium Cocos*. The next year Fries (6) published it as *Pachyma Cocos*, using Schweinitz's description. The observations of MacBride (11) of South Carolina on this fungus were published in 1817 and he gave to it the name *Sclerotium giganteum*.

Later a number of other descriptive accounts were published, as will be indicated subsequently, the most comprehensive of which is

[1] This is very probably the wild potato vine, *Ipomoea pandurata*.

that of Gore (7). This account includes also the results of chemical analyses of the tuckahoe which, in confirmation of the earlier work of Torrey (17), shows that it is largely composed of pectic compounds. Torrey, however, employed the name "sclerotin" which was subsequently found to be identical with the jelly-forming constituents of fruits and tubers to which Braconnot[2] applied the name "pectous substances."[3]

DISTRIBUTION

The tuckahoe is reported to occur from New Jersey southward to the Gulf of Mexico, westward to Texas, and as far north as Kansas, in light loamy or sandy soil. Whether or not the data on distribution of tuckahoe in the accounts of Banning (2), Ravenel (13), Lockwood, (10) Gore, (7), Schreneck (14) and in a recent bulletin from the Missouri Botanical Garden (1) apply to *Pachmya Cocos* alone or include closely related species cannot now be determined. It is my belief, as will be discussed later, that *Pachmya Cocos* is parasitic and is associated only with the roots of pines. However, Lockwood (10) records finding tuckahoe among the roots of willow oak, *Quercus phellos*, in New Jersey. Further, specimens in the herbarium of Bresadola under the name "*Pachma Cocos* Fr. = *Mylitta pinetorum* Horaninow," show sclerotia which are very different from the form under discussion since they are very heavy and in section look like mottled amber.[4] Manifestly, in the absence of widespread knowledge of the identity of *Pachyma Cocos*, and of definite information of its host relationship together with confusion of names in herbarium collections, satisfactory information on distribution is not available.

DESCRIPTION OF SCLEROTIA

The tuber-like structures to which Fries (6) gave the name *Pachmya Cocos* were described by him as "oblong to elliptical in shape with hard scaly bark and with a brown and woody appearance, about the size of a man's head, exactly resembling a cocoanut;

[2] Ann. Chim. phys. **25**: 358-373. 1824.

[3] A transcript from Berkeley and Curtis' manuscript which accompanies their specimens of tuckahoe was given me by Dr. W. C. Coker. These notes include chemical studies by Prof. Ellet of South Carolina College who states that, "Twenty years ago I examined a specimen of it from Virginia. I have repeatedly worked with Carolina specimens of the substance and find them all identical in their nature. It consists entirely of pectic acid or rather the pectin of Braconnot."

[4] From notes made during the summer of 1921 by Dr. W. C. Coker.

bark thick and fibrous in general appearance like a pine root. Within the substance is uniformly whitish to flesh-colored with an odor like a mushroom. They are flesh-colored when they attain their growth, and are considered by the natives as possessing medicinal properties. They are found in Carolina especially among pine forests."

The sclerotia which I have examined show considerable variation in size and shape as shown in plate 34. The largest specimen taken was an oval body 27 inches by 19 inches in circumference and its weight was 3161 grams or approximately 7 pounds. Another was slender and elongated and measured 41 inches in length. When first taken from the earth these masses are of such a consistency as to be easily cut with a knife but on drying they become extremely hard and horn-like and the interior becomes variously cracked and fissured. This fissuring is not perceptible from the exterior, however.

The cortex of the sclerotium possesses the roughed furrowed appearance and color of pine roots. This appearance is simulated best in specimens in which flakes of bark constitute a portion of the sclerotial cortex. When examined microscopically, this cortex is seen to consist of densely compacted fungous cells making a quite well-defined layer 100-150μ in thickness (fig. 7). The interior is whitish or tinged with pink when fresh and becomes grayish when dry. The cells which compose this portion are extremely variable in size and shape as shown in fig. 2.

Origin of Sclerotia

As has been recorded by the several botanists who early described tuckahoe, the habitat of these sclerotia is invariably among the roots of pine trees, *Pinus taeda* and *Pinus rigida*. It would appear improbable that such an association is purely accidental. That they are parasitic, however, seems very probable in the light of the following facts:

1. All of the sclerotia which I have found are in part pine root tissues, but there is, however, neither hypertrophy or hyperplasia of these tissues. In respect to the inclusion of host tissue *Pachyma Cocos* differs from all other known large sclerotia.

In some cases the xylem portions of the pine root extend entirely through small sclerotia and the root is free from bark inside the tuber. If the sclerotium merely surrounded the root, or attached

PLATE 34

A group of tuckahoes, *Pachyma Cocos*. The largest had a weight of seven pounds and the longest a length of 41 inches.

itself to it, the bark should be intact. Such a case has been observed also by Gore (7) and is illustrated in fig. 1 accompanying his account.

2. Sclerotia attached to the roots have been unearthed near the base of living trees.

3. There is no evidence of mycelium or rhizomorphs in the soil surrounding the sclerotia.

4. Sclerotia have been found with portions of roots not only at the end directed toward the tree, but also distal to it. If one follows the course of these roots into the sclerotia, all stages can be found from what appears microscopically to be normal woody tissue to a splitting apart and transformation of the xylem strands, which are few in number toward the outside, but numerous and slender toward the center of the sclerotium (figs. 3 & 4). In large sclerotia all traces of the woody portions of the roots have disappeared at a distance of about one and one-half inches from the end. In forming such sclerotia it seems reasonable to suppose that as they enlarged there was both a stretching apart of the woody tissue of the root and at the same time a transformation of substance appropriated from the root tissues.

5. The roots at some distance from the body of the sclerotium have to the unaided eye, apparently normal bark and wood tissues. Both portions, however, on microscopic examination are found to be invaded and the mycelium completely fills all intercellular and intracellular spaces (fig. 8).

Several investigators have held that the tuckahoe is to be regarded as an altered or transformed state of the root. Gore (7) concludes that such is the case in his discussion of their origin in which he states that "Specimens in all stages of development are in my possession from the root with only a film of the substance between the bark and the woody part of the root up to pieces six inches in diameter." MacBride (11) states that the growth originates between the bark and wood of living trees, that it gradually enlarges, detaches the bark and transforms the root tissues into its own substance. Another observer quoted by Gore (7) in a letter to him states that "this growth had taken place from the roots of pines as was evident from some having just commenced growing, the pine root extending through and reaching out on each side. Others had

developed to considerable size showing no appearance of any root in them or any bark of the pine on the outside as was the case with the smaller ones. I think the whole root for two inches or more is changed into this substance from the fact that some of the roots extend entirely through it, some of them being smaller inside and larger outside."

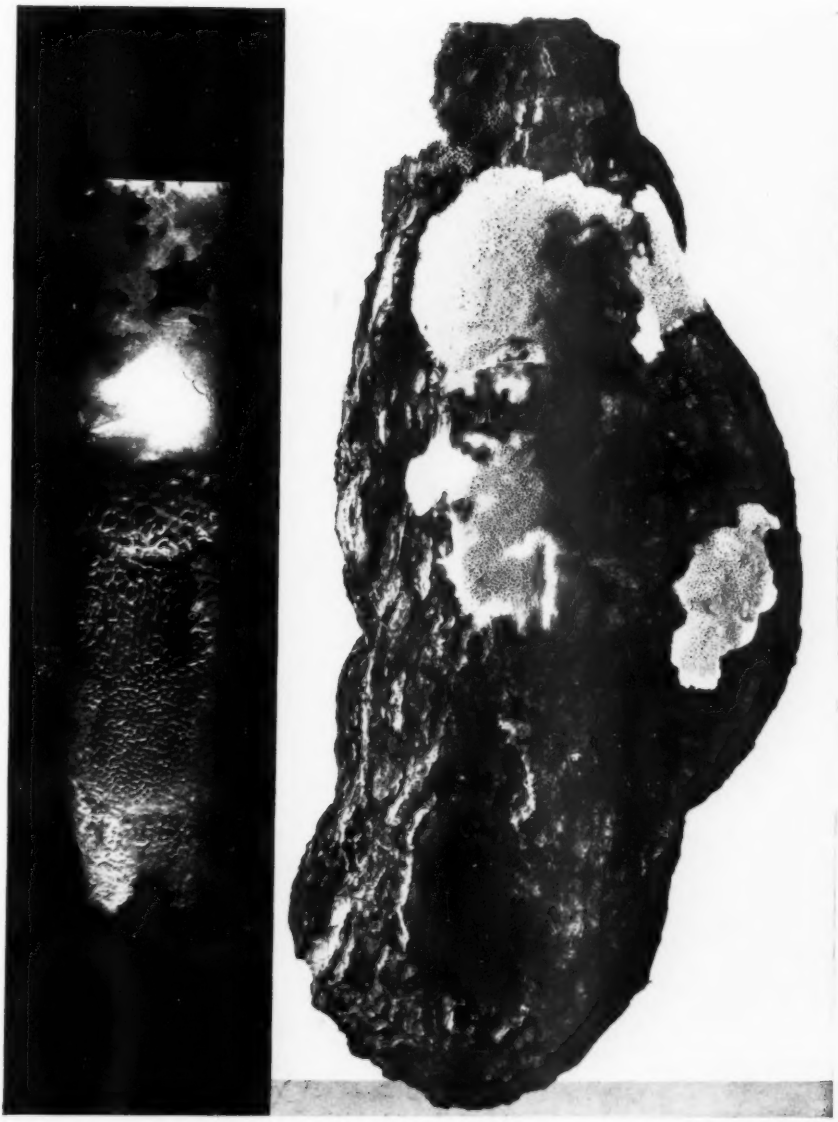
The observations of Ravenel (13) alone cast doubt on the parasitic origin of the tuckahoe. He records the finding of five or six specimens varying in size from a hen's egg to more than twice as large, attached to an old pine rail. Since all other observers agree in the occurrence of tuckahoes singly and not in groups, there is a possibility of mistaken identity by Ravenel.

FORMATION AND STRUCTURE OF THE SPOROPHORE

In efforts to bring about the production of fruit bodies several sclerotia which had been subjected to drying in the laboratory for a few days after collection, were placed in water to soak for about 24 hours. One was then left to lie on a laboratory table, one in a moist chamber in the laboratory, two were placed in an ice chest, one was placed in a moist chamber in a photographic dark room and three were buried out of doors in the sand. In three days, a dense white fungoid crust had formed in the case of the first one on the side in contact with the table. As I did not suspect that this crust was an immature resupinate hymenophore, since I was looking for a stalked fruit body to make its appearance, I scraped off most of it in making examination and left it lying with the crust upward. Several days later, I was surprised to find that a similar crust had formed on the opposite side. This was undisturbed and in the course of a week had matured into the hymenial layer. The one in the moist chamber had meanwhile developed a fruit body similar in appearance. The two tuckahoes in the ice chest showed no signs of growth during two weeks there. They were then placed in a moist chamber in the laboratory where within a week both fruited. One formed four fruiting structures and is the one shown in plates 35 and 36.

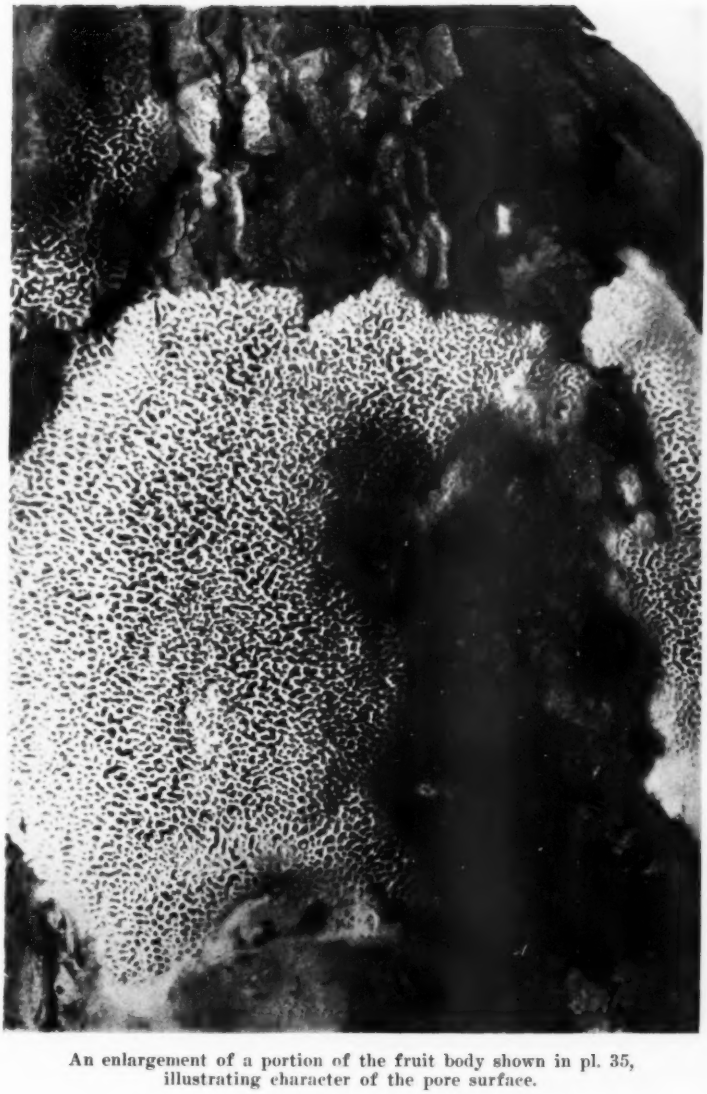
In the case of the sclerotium in the dark room, a profuse loose mycelial envelope which completely surrounded it had formed in two weeks. When after this time it was subjected to the diffuse light

PLATE 35



Fruit body developed in a test tube from bit of tissue from center of a sclerotium [left].
Several resupinate fruit bodies on one sclerotium [right].

PLATE 36



An enlargement of a portion of the fruit body shown in pl. 35, illustrating character of the pore surface.

of the laboratory several diminutive fruit bodies formed on its surface within a week.

The sclerotia which were buried were examined after two weeks and were found to have surrounded themselves with a loose weft of mycelium (fig. 1) which was whitish at first and became at length tawny. Two weeks later these sclerotia were largely decayed.

Several unsuccessful attempts were later made to bring into fruiting specimens which had dried out from exposure in the laboratory. These experiments, which have resulted in the development of sporophores on five tuckahoes,[5] indicate that fruiting is conditional upon at least three factors, (1) fresh specimens, (2) saturation with water. and (3) the presence of light.

In efforts to artificially culture this organism, a bit of tissue from near the center of a large sclerotium was transferred with aseptic precautions on May 2 to a potato plug. A loose white mycelium developed and on May 23rd a poroid sporophore somewhat abnormal in appearance but with mature normal spores entirely similar in size, shape and appearance to those in nature, had formed.[5]

The sporophores are resupinate, plate 35, and although pure white at first they become with age slightly tinged with brown. The subiculum is thin. The pores are large and angular to irregularly sinuous and 2-3 mm. deep, plate 36. The hymenium is at first rather tough and cartilaginous but becomes papery on drying. There is no sterile margin nor are cystidia present. The basidia are blunt, club-shaped, 20-25μ in length and 6-8μ in width and are crowned with four rather slender sterigmata, fig. 9. The basidiospores are white in mass, asymetrically cylindrical, smooth, and 7-8 x 3.5μ, Fig. 10.

[5] After receiving this paper for publication, I suggested to Dr. Wolf that he make still further cultures so as to place the proof of relationship of the *Poria* to the tuckahoe beyond all doubt. He accordingly made six other cultures on potato plugs sterilized in glass tubes and inoculated with tissue taken from the center of three large tuckahoes. The latter were collected during the last week in April and had been left to lie in the laboratory until June 22nd, the date on which the cultures were made. By July 17th each of the six cultures had formed fruiting bodies of the *Poria* type and one of these is shown in plate 35. Dr. Wolf has also produced another fruiting body on the surface of a tuckahoe since writing this paper. A sclerotium was soaked and buried in sand for three weeks, during which time it enveloped itself with a loose, white weft. It was then dug up and put into a moist chamber. Within ten days it had formed on its surface the most perfect fruiting body that he has obtained This makes a total of six tuckahoes that have produced sporophores on their surface. The plant had been buried to test the possibility of production of a stalked sporophore. The result confirmed the previous conclusion that light is a necessary stimulus to production of a fruit body. Just as this paper was going to press there was published by Elliott an article on "Some Characters of the Southern Tuckahoe" (Mycologia **14**: 222. 1922). His specimens were not attached to pine but supposedly to sumac roots in two cases. Efforts to secure a fruiting stage were not successful, and the identity of his plant with Wolf's species must remain in doubt.—W. C. COKER.

The fruiting of *Pachyma Cocos* is manifestly of the type characteristic of the genus *Poria* which is recognized to include a heterogeneous group of forms but it is provisionally placed in this genus.

When comparison is made with the descriptions in literature of fungi arising from large sclerotia none of them are found to bear any resemblance to our specimens. *Grifola Tuckahoe* Güssow (8), for example, has coal black sclerotia with a blackish interior and its fructifications are fleshy, stipitate, ochre to yellowish brown structures. *Polyporus tuberaster* (Jacq.) Fries as first illustrated by Micheli (12) shows this species to possess an irregular, globular, sclerotium enclosing stones and earth, from which arises a stipitate polypore with angular pores. *Polyporus Sapurema* Möller from Brazil has an enormous sclerotium from which a large fleshy stipitate fruit body is developed. *Lentinus tuber regium* Rump. is a large, stipitate, gill-bearing form. In fact, all hitherto known large sclerotia whose fruiting stages have been found have large sporophores whereas our specimens bear small fruit bodies. Further, no other species of *Poria* is known to have a sclerotial stage. It is for these reasons that C. G. Lloyd to whom specimens were sent for determination is of the opinion that it is very improbable that there could be any relationship between tuckahoe and *Poria.*

The question of a species name is much more difficult since to determine whether or not this form is different from previously described species would involve a thorough-going study of all known resupinate forms. Since, however, *Pachyma Cocos* is believed to be parasitic and consequently its fruiting stage in all probability occurs only on the surface of the sclerotia, it is entirely unlikely that it has been observed or collected previously. The combination *Poria Cocos,* is therefore proposed in order to connect our fungus with the long known sclerotial stage name, with the following brief diagnosis.

Poria Cocos (Schw.) comb. nov.

Sclerotium giganteum Macbride. Trans. N. Y. Phil. Soc. 1817.
Sclerotium cocos Schw. Syn. Fung. Car. Sup., p. 56. 1822.
Pachyma cocos (Schw.) Fries. Syst. Mycol. 2: p. 242-243, 1823.*

* Other synonyms given by Gore are:
P. solidum Oken. Lehrbuch d. Naturgesch. 2 ter Thiel. Botanik 2 ter Abtheil, 1 te Halfte, 1815.
P. pinetorum Horaninow, p. 2-23, 1856.
P. coniferarum Horaninow. (See continuation on p. 135).

Sporophoris resupinatis, albidis deinde pallide ferrugineis, membranaceis—crustaceis; tubulis 2-3 mm. long, cartilaginis, siccatis chartaceis; ore crassi, irregulari vel labyrinthiformi; margine non sterili; cystidiis nullis; basidiis clavatis, 20-25 x 6-8μ; sporis hyalinis inaequilateralibus, oblongis, levibus, 7-8 x 3.5-4μ.

Hab. ad sclerotia in vivis radicibus Pini. Sclerotium magnum, oblongo-subrotundum, arrhizum; cortex crassus, fibroso-squamosus, durus, colore radicum Pinorum; intus cellis radicorum Pini atque materia carnoso-suberosa repletum, odore fungoso-farinacea. In terra praesertim in pinetis sabulosis.

Specimens have been deposited in the herbarium at the University of North Carolina, Chapel Hill, N. C., at the Lloyd Library, Cincinnati, Ohio, and at the Missouri Botanical Gardens, St. Louis, Mo.

Special thanks are due to Dr. W. C. Coker, for his courtesy and help in connection with the preparation of this report and to Mr. C. G. Lloyd for his opinion as to the identity of the fungus.

SUMMARY

This study of the southern tuckahoe, *Pachyma Cocos*, includes an account of its history, structure and origin together with the development and morphology of its fruiting stage.

The name tuckahoe is of Indian origin and was applied by them to all edible roots and tubers. It has come to be used by botanists, however, to include only certain subterranean fungous growths or sclerotia.

The tuckahoe has been known to botanists for about 175 years but its fruiting stage has not hitherto been described. Pine root tissues are always included within this tuckahoe and it is apparently parasitic upon the roots of pine.

Several conditions which include (1) fresh sclerotia, (2) their saturation with water and (3) exposure in light govern the production of sporophores. Mature sporophores of the *Poria* type have been secured on the surface of six tuckahoes. A period of about a week's duration is necessary for their complete development. The

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Lycoperdon solidum Clayton. Flora Virginica, p. 176. 1762.
L. sclerotium Nuttal. Systematic and Physiological Botany, p. 200. 1820.
L. cervinum Walter. Flora Caroliniana, p. 262. 1788.
Tuckhaus rugosus Rafinesque. Med. Flora of N. America **2**: 255. 1830.
In such of these as we have seen, the description is too imperfect to refer with any certainty to our plant.

fruiting stage has also been developed in cultures from tissue taken from near the center of large sclerotia.

This *Poria* is herein given the name *Poria Cocos* to relate it to its tuckahoe stage.

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EXPLANATION OF PLATE 37

Fig. 1. Hypha from mycelial envelope of sclerotium as it appears when sclerotia are buried or put into the dark room.
Fig. 2. Variation among the cells which compose the interior of the sclerotium.
Fig. 3. A diagrammatic section of a sclerotium with three groups of woody tissue and one of bark remaining. Proportional sizes are shown.
Fig. 4. Diagram of a section of an apparently normal root and of a sclerotium. The sections are about one and one-half inches distant from each other. The woody elements have become separated into seven groups. Relative sizes are preserved.
Fig. 5. A diagram of a sclerotium showing relative sizes in cross section of the woody elements. The sections are about an inch distant from each other.
Fig. 6. All of the xylem elements have been destroyed in this section but much of the bark remains although it is densely filled with fungous hyphae.
Fig. 7. Section of the compact sclerotial wall together with the less dense subjacent tissue.
Fig. 8. Xylem cells from apparently normal tissue.
Fig. 9. Basidia of *Poria Cocos*.
Fig. 10. Basidiospores.
Fig. 11. Tissue from a rhizomorph which formed from a sclerotium which was unearthed and then partially buried in leaf mold for two months.
Figs. 1, 2, 7, 8, 9, and 11 are drawn to the same scale.

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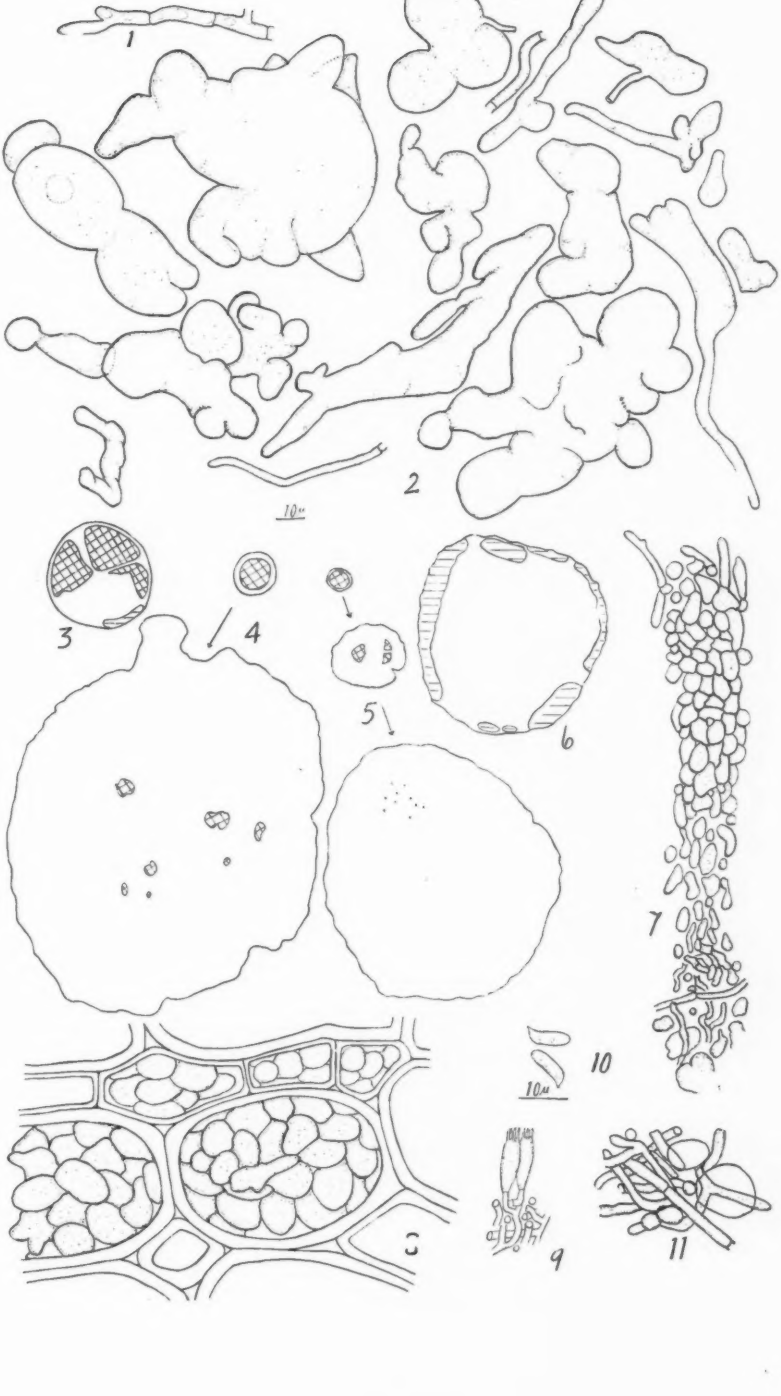
PLATE 37



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